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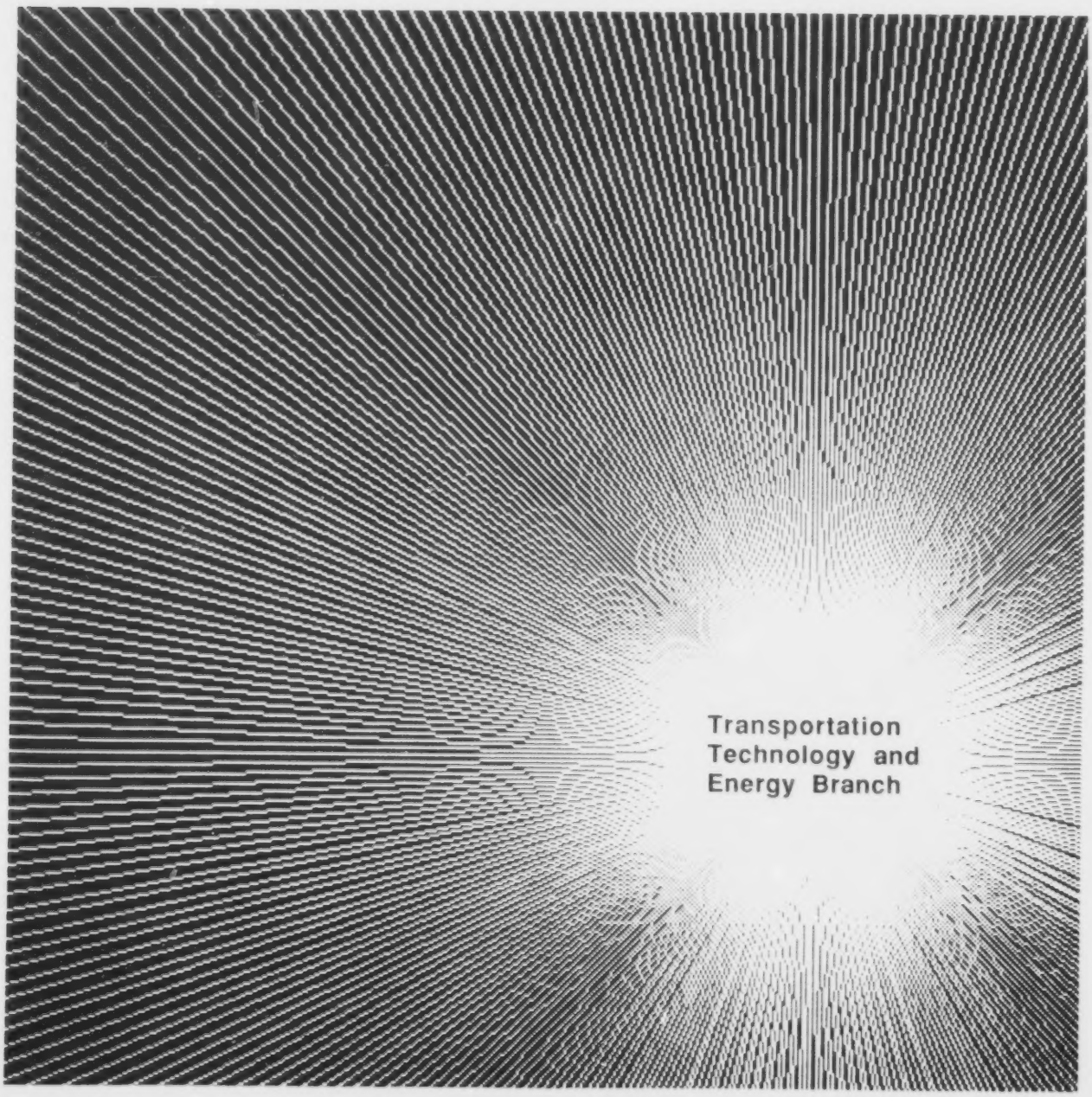

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Economics of Liftable Axles

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Economics of Liftable Axles

Prepared by: **Fred Nix and Professeur Michel Boucher**

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Abstract: This report summarizes research into the economic and operational aspects of trucks in Eastern Canada with liftable axles under a number of possible regulatory scenarios. Trucks with liftable axles are popular in Eastern Canada – they account for almost one-third of total truck freight tonnages – because they offer carriers a way of increasing payloads for heavy, dense freights. Shippers and the consuming public benefit from the existence of liftable axles as their use has meant lower transportation costs. Nevertheless, there are concerns about the use of liftable axles – their use is prohibited in Western Canada. The concerns revolve around issues of safety and road damage, none of which is investigated here. Rather, the purpose of this research is to analyze the implications on trucking of a number of options, leaving for others the task of making trade-offs between possible increases in trucking costs versus various road improvements.

Five regulatory scenarios are investigated. The findings of a cost analysis suggest there are alternative trucks available, which do not involve the use of liftable axles, and which can often haul freight at costs comparable to liftable-axle equipment. Second, the research shows that none of the regulatory options has a major impact on total trucking costs. None of the scenarios investigated – including an outright ban on liftable axles – increased total trucking costs by more than 1%. Some individual operations, of course, would see cost increases in the range of 10 to 20%.

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16. Abstract

This report summarizes research conducted in Eastern Canada into the economic and operational aspects of trucks with liftable axles. A number of possible regulatory scenarios were considered. Trucks with liftable axles are popular in Eastern Canada - they account for almost one-third of total truck freight tonnages - because they offer carriers a way of increasing payloads for heavy, dense freights. Shippers and the consuming public benefit from the use of liftable axles, as it lowers transportation costs. Nevertheless, there are concerns about their use. In Western Canada, it is prohibited. The concerns involve issues of safety and road damage, which are not investigated here. Rather, the purpose of this research is to analyse the implications on trucking of a number of options, leaving for others the task of making trade-offs between possible increases in trucking costs and various road improvements.

Five regulatory scenarios are investigated. The findings of a cost analysis suggest there are alternative trucks available, which do not use liftable axles, and which can often haul freight at costs comparable to liftable-axle equipment. The research also shows that none of the regulatory options has a major impact on total trucking costs. None of the senarios investigated - including an outright ban on liftable axles - increased total trucking costs by more than 1%. Some individual operations, of course, would see cost increases in the range of 10 to 20%.

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16. Résumé

Ce rapport résume la recherche technico-économique menée dans l'Est du Canada sur les essieux relevables. Un certain nombre de scénarios intéressant la réglementation ont été examinés. Les poids lourds équipés d'essieux relevables sont très répandus dans l'Est du Canada - où ils transportent près du tiers du trafic routier total de marchandises - car ils permettent d'augmenter la charge utile dans le cas de marchandises lourdes et denses. Les transporteurs et les consommateurs y trouvent leur compte, en raison de l'abaissement du coût du transport routier. Mais ces essieux soulèvent de graves préoccupations, au point que leur utilisation a été interdite dans l'Ouest du Canada. Ces préoccupations concernent aussi bien la sécurité routière que l'endommagement des chaussées, que la recherche n'a cependant pas abordés. Celle-ci a eu plutôt pour objet d'approfondir l'effet sur le camionnage des divers scénarios envisagés, laissant à d'autres la tâche d'arbitrer les choix qui se présentent entre coût plus élevé du transport routier et coût du renforcement des chaussées.

Cinq scénarios de réglementation ont été approfondis. Une analyse des coûts a mis en évidence la possibilité d'utiliser des matériels qui, sans être équipés d'essieux relevables, peuvent assurer le transport routier à un coût comparable. Elle a montré en outre qu'aucun des scénarios envisagés n'a un impact sensible sur le coût global du camionnage, l'augmentation maximum prévue s'établissant à 1 p. 100, même dans le cas de l'interdiction pure et simple des essieux relevables. Cependant, il se pourrait que certains secteurs du transport routier aient à subir des augmentations de l'ordre de 10 à 20 p. 100.

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Notwithstanding all of this excellent assistance, the authors are responsible for the findings, the opinions expressed, and, of course, any errors that may have inadvertently crept into these pages.

EXECUTIVE SUMMARY

The provinces in central and Atlantic Canada, under current regulations, allow carriers to use liftable axles on heavy trucks. This increases payloads considerably, for a small increase in both tare weight (weight of the equipment) and operating costs. Not surprisingly, then, liftable axles offer carriers a means of hauling heavy, dense freight at a lower cost than otherwise would be possible. This report summarizes research into the economic and operational aspects of trucks with liftable axles under a number of possible regulatory scenarios.

Trucks with liftable axles now account for something in the range of 27 to 31% of total truck freight tonnages in the six eastern provinces. The following example shows why these trucks are so popular:

	Ontario 5-axle tractor-semi-trailer dry freight van	Ontario 6-axle (1 liftable) tractor-semi-trailer dry freight van	% Change
Gross weight (tonnes)	42.0	52.0	+ 23.8%
Tare weight (tonnes)	15.9	17.0	+ 6.9%
Payload (tonnes)	26.1	35.0	+ 34.1%
Total costs/kilometre ($)	1.52	1.68	+ 10.7%
Costs/tonne-kilometre (cents)	6.10	5.04	- 17.4%

While the tare weight of this truck increases by 7%, the payload increases by a significant 34.1%. Similarly, while the cost of operating the six-axle configuration is about 11% higher than the five-axle configuration, freight costs drop by 17%.

The figures in this example depend on the specific values of certain parameters: length of haul, factor prices, productivity, the type of tractor and trailer used, and so on. So, while it would be a mistake to apply the above numbers to all situations, it remains generally true that a six-axle tractor-semitrailer with a liftable axle can haul freight at a considerably lower cost than can a five-axle tractor-semitrailer. Note that only heavy, dense freight benefits from the existence of trucks with liftable axles; many carriers haul low-density freight – things like automobiles or consumer products – and, so, have no interest in this subject.

While shippers of these products and, ultimately, the consuming public, benefit from the existence of liftable axles in eastern Canada, there may be drawbacks to their use. In fact, when all provinces signed an agreement in 1988 for uniform weight and dimension regulations in Canada, the concern over liftable axles was so great that liftable axles were banned in those provinces not already allowing their use. The

concerns about the performance of liftable axles revolve around issues of safety and infrastructure use. Specifically, research has shown that liftable axles may reduce a truck's stability in some situations – that is, potentially may decrease highway safety. Highway departments believe the existence of liftable axles makes enforcement of axle-load regulations difficult. As a result, these agencies believe liftable axles may pose a threat to pavements and bridges – that is, may wear out highway infrastructure prematurely. None of these stability, enforcement, or road-impact issues is investigated here. Rather, the purpose of this research is to analyze the cost (freight costs) and operational implications of a number regulatory options, leaving for others the task of making the trade-offs between possible increases in trucking costs (freight costs) versus various improvements to the road system (road costs).

The regulatory scenarios investigated are:

1/ Current truck configurations with liftable axles at current axle-load limits (10.0 or 9.0 tonnes, depending on the province).

2/ Liftable axles held to a maximum of 8 tonnes.

3/ Liftable axles held to a maximum of 6 tonnes.

4/ Liftable axles banned.

5/ Liftable axles allowed at current loads, but restricted to one liftable axle per truck or tractor-semitrailer combination.

These are just a number of arbitrarily selected scenarios designed to capture a wide enough range of options to allow all possibilities to be investigated. There is no intention of suggesting any one of these policies is the right choice for a particular province.

The research can be summarized by two broad observations. First, the research shows there are alternatives to liftable-axle configurations. This is a complex subject. It is complex because there are a great many configurations in use and a great many aspects to particular hauling situations favouring one of these over another. Setting aside this complexity, the findings of a detailed cost analysis suggest there are choices available, that do not involve the use of liftable axles, and that can often haul freight at costs comparable to liftable-axle equipment. Consider just one example (again, this is only one of a very large number of possible examples):

Quebec gravel trucks	Hauling costs per tonne-kilometre (cents)	Comparison (index)
6-axle (1 liftable) tractor-semitrailer	9.48	100.0
6-axle tractor-semitrailer ("tridem")	10.32	108.9
6-axle truck plus ("pup") trailer	9.26	97.7
Quebec 8-axle B-train (59.0 t)	10.79	113.8
RTAC 8-axle B-train (62.5 t)	10.00	105.5

Notice that one of these alternatives – the truck-trailer – actually can haul gravel at a lower cost than the popular six-axle tractor-semitrailer, and that the other configurations can haul gravel at costs only a little higher.

Second, the research shows that none of the regulatory options has a major impact on total trucking costs in eastern Canada. (Transition costs, however, were not considered.) At the extreme, an outright ban would increase freight costs by something in the order of $100 million or, just over 1% of total industry operating costs of $8.9 billion (1987). But this is the extreme estimate. The other extreme – the low end of the estimates – is that an outright ban on liftable axles would actually decrease trucking costs, admittedly, by a small amount. It is more likely, though, that the actual impact of any scenario investigated lies between these two extremes. Perhaps freight costs – that is, total trucking costs – would increase by several million dollars or about half a percent of total industry costs. Some individual operations, of course, would be affected by somewhat more than this; a few would see cost increases in the range of 10 to 12%.

SOMMAIRE-SYNTHESE

Ce rapport résume les principaux résultats de la recherche sur les aspects économiques et opérationnels de camions munis d'essieux relevables. L'approche utilisée consiste à envisager différents scénarios sur les charges admissibles que pourraient transporter ces configurations. Les camions dotés d'essieux relevables qui opèrent actuellement au Québec, en Ontario et dans les provinces de l'Atlantique permettent aux transporteurs d'accroître considérablement la charge utile tout en n'entraînant que des hausses minimes des coûts d'opération et des poids nets des camions. Il n'est pas surprenant alors que ces configurations permettent aux entreprises de transporter des marchandises lourdes et denses à des coûts plus bas qu'il en serait possible autrement.

Les camions ayant des essieux relevables s'approprient maintenant entre 27 et 31% de toutes les tonnes de marchandises que transportent les entreprises de transport routier opérant dans les six provinces de l'est du Canada. L'exemple suivant, qui porte uniquement sur le transport de marchandises générales qui se réalise au moyen de semi-remoques standard, est tiré du modèle des coûts de l'Ontario. Il fait aussi voir les raisons de leur popularité auprès des transporteurs:

Transport de marchandises générales par:

	Tracteur et semi-remorque de 5 essieux	Tracteur et semi-remorque de 6 essieux dont un est relevable	% variation
Poids nominal brut	42,0	52,0	+23,8
Le poids net	15,9	17,0	+6,9
La charge utile	26,1	35,0	+34,1
Coûts totaux/kil.$	1,52	1,68	+10,7
Coûts/tonne-kilomètre (cents)	6,10	5,04	-17,4

Ainsi alors que le poids net du camion s'accroit de 7%, le poids total en charge augmente fortement, soit de 34,1%. De même, pendant que les coûts d'opération d'une configuration de 6 essieux sont de ll% plus élevés que ceux d'un 5 essieux, les coûts de transport diminuent de 17%.

Les données de cet exemple dépendent naturellement des valeurs spécifiques de certains paramètres comme la distance parcourue, les prix des facteurs de production, la productivité, la sorte de tracteur et de semi-remorque employée et ainsi de suite. Alors que cela constituerait une erreur de transposer ces dernières valeurs à toutes les situations, il n'en demeure pas moins vrai qu'un tracteur et une semi-remorque de 6 essieux, dont l'un est relevable, peut transporter des marchandises à un coût considérablement inférieur à une configuration ayant 5 essieux. Il convient de noter que les bénéfices de l'existence des camions dotés d'essieux relevables ne vont qu'aux marchandises lourdes et denses; les transporteurs de marchandises de faible densité comme les automobiles ou les produits de consommation n'ont évidemment aucun intérêt envers cette forme d'équipement.

Alors que les expéditeurs de ces produits denses et lourds et ultimement les consommateurs profitent de l'existence des essieux relevables dans l'est du Canada, leur utilisation occasionne tout de même des inconvénients. En effet, quand toutes les provinces ont signé, en l988, une entente pour uniformiser les normes de charges et dimensions des véhicules, l'existence des essieux relevables était si préoccupante que ces derniers ont été bannies par les provinces qui ne les autorisaient déjà pas. Les inquiétudes sur la performance générale des essieux relevables tournent autour de leur sécurité et de leur impact sur l'infrastructure. Plus spécifiquement, des recherches démontrent que les essieux relevables peuvent réduire la stabilité intrinsèque des camions dans certaines circonstances, c'est-à-dire peuvent réduire potentiellement la sécurité sur les autoroutes. De plus, les directions des autoroutes des ministères des transports croient que la présence des essieux relevables rend plus difficile l'application des normes en matière de charges axiales. Par voie de conséquences, ces organisations publiques croient que les essieux relevables peuvent constituer une menace éventuelle aux ponts et chaussées, c'est-à-dire endommager prématurément les infrastructures routières. Cependant, aucun de ces points, la stabilité des véhicules concernés, l'application des charges axiales, ou les conséquences de la charge axiale sur les infrastructures, n'est abordé dans cette recherche. Le but de cette recherche consiste plutôt à présenter les implications du trade-off ou arbitrage "camions-coûts" qui résulte de certaines modifications de la réglementation en matière de charges axiales, laissant à d'autres chercheurs le soin de faire de tels arbitrages entre des hausses possibles des coûts de transport routier et différentes améliorations au système routier sous la forme de coûts de voirie.

Les scénarios de politique considérés, bien qu'arbitraires, visent essentiellement à présenter un éventail d'options raisonnables, permettant ainsi d'en mesurer les impacts en termes monétaires. Il n'est nullement dans nos intentions de suggérer que l'un ou l'autre de ces scénarios constitue le bon choix pour une province donnée. L'évaluation porte uniquement sur cinq scénarios qui sont les suivants:

1/ le maintien des configurations actuelles des véhicules dotés d'essieux relevables aux normes courantes de charge axiale (10 ou 9 tonnes selon les provinces);
2/ la charge axiale autorisée serait établie à 8 tonnes par essieu relevable;
3/ la charge axiale par essieu relevable serait fixée à 6 tonnes;
4/ la suppression totale de l'utilisation des essieux relevables;
5/ les essieux relevables continueraient de transporter les charges autorisées, mais leur utilisation serait restreinte à un essieu relevable par camion ou combinaison de camions et semi-remorques.

Cette recherche se résume en deux grandes observations. Premièrement, il existe plusieurs configurations substituts aux configurations actuellement munies d'essieux relevables. C'est un sujet complexe. Il y a, en effet, une grande variété de configurations de véhicules en opération et il existe plusieurs éléments, propres à chacune des situations de transport des marchandises, qui favorisent une des ces configurations sur toute autre. Si nous ne prenons pas en compte ces relations complexes, les résultats de l'analyse détaillée des coûts démontrent qu'il existe des choix disponibles de configuration, qui ne comportent pas d'essieux relevables, et qui permettent aussi de transporter des marchandises à coûts qui se comparent à ceux de configurations ayant des essieux relevables. L'exemple suivant tiré en modèle des coûts au Québec, se réfère aux diverses possibilités de transporter du vrac:

	Coûts de transport par tonne-kilomètre (cents)	Indice de comparaison
Tracteur et semi-remorque de 6 essieux dont l'un est relevable	9,48	100,0
Tracteurs et semi-remorque de 6 essieux (tridem)	10,32	108,9
Camion et remorque de 6 essieux	9,26	97,7
Train B de type Québec de 8 essieux (59,0t)	10,79	113,8
Train B de type RTAC de 8 essieux (62,5t)	10,00	105,5

Ainsi il convient de noter que l'un des substituts - le camion et remorque - peut transporter du vrac à un coût inférieur à celui d'un tracteur et semi-remorque standard de 6 essieux, dont un est relevable. Une précision est de mise à savoir que le train B de type Québec et le train B de type RTAC sont des sortes particulières de configurations ayant deux remorques et que la configuration dite tridem est une semi-remorque ayant un regroupement particulier d'essieux. Deuxièmement, aucune des options de politique retenues, incluant même la suppression totale des essieux relevables, n'a de conséquence importante sur les coûts globaux des entreprises opérant dans les provinces concernées. Les coûts de transition ne sont toutefois pas considérés. A titre d'illustration, la suppression des essieux relevables n'augmenterait les coûts de transport que d'environ 100 million $, soit un peu plus de 1% des coûts d'opération de l'industrie canadienne, évalués à 8,9 milliards $ en 1987. Toutefois, ce dernier résultat est définitivement une borne supérieure extrême. Si on regarde à l'autre extrémité du spectre des scénarios, il est même possible que les coûts de camionnage puissent diminuer si les essieux relevables étaient bannis. Donc, l'impact véritable de l'un ou l'autre des différents scénarios considérés se situe, selon toute vraisemblance, entre ces deux extrêmes, c'est-à-dire une hausse des coûts de transport de quelques millions de dollars ou une augmentation de la moitié de 1% des coûts de toute l'industrie canadienne. Il est toutefois possible que certaines opérations de transport de marchandises soient affectées davantage que ces estimés.

1/ INTRODUCTION

The purpose of this study is to evaluate the cost and operational characteristics of large trucks with and without liftable axles.

Items specifically excluded from the study are:

- Highway infrastructure: the study does not examine the impact trucks have on pavements, bridges, geometric design, capacity, or other traffic considerations.

- Safety: the study does not consider the different accident rates of various truck configurations, stability considerations, or public perceptions about large trucks.

The terms of reference of the study define the development of costs as follows:

> "Costs shall be addressed in annual terms, assuming in all cases that fleets are stable and mature. Costs associated for transition between scenarios are not required. Costs shall be addressed for both intra-provincial and inter-provincial operations, assuming fleets configured under current regulations. Annual costs shall be identified on a tonne-kilometre basis for comparison of the scenarios . . . Costs shall include all capital, operating and maintenance costs. They should be assessed on a vehicle unit basis, and also aggregated to industry as a whole."

The costs developed in this research do not include transition costs – that is, costs associated with switching from one truck configuration to another. These costs could be substantial or they could be quite small, depending on how regulations were changed. The task of this research, however, is not to examine how regulations might be changed; it is only to try to estimate the impact on trucking costs once all changes have occurred.

The regulatory scenarios evaluated are as follows:
- Scenario #1: current truck configurations with liftable axles at current axle-load limits
- Scenario #2: liftable axles held to a maximum of 8 tonnes
- Scenario #3: liftable axles held to a maximum of 6 tonnes
- Scenario #4: liftable axles banned
- Scenario #5: liftable axles allowed at current loads, but restricted to one liftable axle per truck or tractor-semitrailer combination.

2/ METHODOLOGY

The study methodology is as follows:

- First, a range of relevant trucks is identified. "Relevant" means those trucks with liftable axles or those that are reasonable alternatives. The study is concerned with large trucks and tractor-semitrailer combinations designed to carry heavy, dense freight.

- Second, a cost model is developed based on Trimac's biannual estimates for Transport Canada [1]. The advantage of this approach is that the study does not concern itself with the issue of the appropriate level of factor prices.

- Third, information from industry is used where detail greater than that available from Trimac is required.

- Fourth, costs per tonne-kilometre are calculated.

- Fifth, using available Statistics Canada data and data from provincial road-side surveys, estimates are made of total freight flows by truck configuration.

- Sixth, the cost of total freight movements under each of the regulatory scenarios is developed.

The following paragraphs elaborate on this methodology.

Relevant Trucks: Trucks in three regions (Ontario, Quebec, Atlantic Canada) are examined. Treating Atlantic Canada as one homogeneous region is an oversimplification, which is acceptable in this case as there is only one liftable-axle combination involved, and the minor differences in regulations from province to province do not have much impact on this configuration. For simplicity, the trucks of New Brunswick are used to represent all of Atlantic Canada.

The range of trucks includes two estimates of axle loads and GVWs; seven body styles (van, refrigerated van, flat, tank, dump, hopper, and log); and five regulatory scenarios (current, 8-tonne liftable axles, 6-tonne liftable axles, no liftable axles, liftable axles at current weights but limited to one per truck). This range does not encompass every truck on the road. That is, aside from the omission of some body styles (e.g., low bed, wood chip, cement), there are other trucks not important to the analysis (e.g., small trucks used on urban pickup and delivery). Only trucks using liftable axles or those that are substitutes for trucks using liftable axles are of interest. So, for example, the RTAC A-train is not included in the analysis as it is only capable of hauling low-density freight.

Costing methodology: Trimac factor prices for 1988 are used for such things as labour rates and other factors not sensitive to regulatory changes considered here. Trimac factor prices are used with modification for such things as equipment prices which are critical to an analysis of the regulatory changes under consideration. Trimac productivity assumptions, such as load/unload rates, are used as a base upon which to develop factors for this analysis. The cost model follows these divisions:

- region
- configuration, by GVW/axle load, by body style
- regulatory scenario
- tare weight (high, low)
- payload (max, high)
- factor prices (Trimac, plus those developed here)
- productivity assumptions (Trimac plus those developed here for such things as: backhauls, load/unload, annual kilometres travelled or hours worked, the effect of axle-spreads or loads on costs, etc.)
- haul distance (using Trimac's 160 km as a base)
- costs per unit of output (kilometre, tonne, tonne-kilometre)

Even at this level of detail, not every conceivable trucking operation can be included. The attempt, though, is to include a broad enough range of costs that most trucking operations using liftable axles can be examined. The aim is to develop an accurate estimate of the relative difference in annual trucking costs from one configuration to another; it is not to develop estimates of the absolute level of trucking costs. This last point is important. To reiterate, there is no claim being made here that the trucking costs are an accurate reflection of any particular trucking operation. They use Trimac information on factor prices as a bench mark; the intent of the analysis is to determine how trucking costs vary from one configuration to another using a common bench mark for such things as labour rates, fuel prices, equipment prices, and so on.

Industry information: Information from industry sources is used for such things as:

- equipment tare weight;
- equipment prices;
- differences in operating costs (tires, maintenance, fuel consumption) for equipment with and without liftable axles;
- differences in productivity (payload, load/unload time) for equipment with and without liftable axles;
- operational advantages/disadvantages of equipment with and without liftable axles.

The attempt is not to develop a statistically valid survey of all truck operators. That is impossible within the scope of the study. Rather the attempt is to develop a range of figures encompassing most operations. In many cases, then, "high/low" figures and/or assumptions are used.

Trucking costs: Costs are developed in a Lotus 123 spreadsheet so that changes in data can be made readily, so that "what if" questions can be posed, and so that specific situations and/or scenarios can be evaluated. Although these costs cannot address all issues, they are the most robust part of the analysis. That is, these individual truck costs are a more precise and reliable guide to policy than the aggregate industry costs (total freight flows) where the difficult problem of associating flows with configurations hampers the efforts at accuracy.

Freight flows: Statistics Canada's 1987 freight flows are used as the base upon which to aggregate the individual truck costs to industry totals. The difficulty, as always in this sort of work, is to find data on the relationship of these flows to truck types. The only, albeit limited, source of information for this is the road-side surveys in Ontario, Quebec, and the Atlantic provinces.

Costing Freight Flows: In this part of the analysis, individual trucking costs are associated with estimates of truck flows. Given the state of the available data, it is not possible to be very precise. Rather, the attempt is to determine if one or another of the scenarios involves a "big" change or a more "modest" change or, perhaps, a "very minor" change. It is, therefore, a question of degree and the final outcome of this research is like an ordinal ranking of the various scenarios' results.

3/ CONFIGURATIONS

This section describes the trucks under study and the reasons for including or excluding certain configurations. More detail is provided in Appendix A. There are many truck configurations, each defined by the type of power unit (truck or road tractor), the number and type of trailers, the number of axles, the manner of combination (dollies, drawbars, fifth wheels, etc), suspension systems, axle spreads, wheelbase, and other features. There is also a broad range of body-styles (van, flatdeck, tank). Ontario has the largest variety of configurations because its regulations, unlike those of other provinces, do not define or control vehicle configuration. It is not possible to include all of these, or even all of the more limited number used in Atlantic Canada, in this analysis. Fortunately, it is not necessary to be this thorough, as information developed on the more common trucks can be generalized to provide broad observations on relative costs.

The interest here is in trucks that may be affected by policy changes on liftable axles. For this reason, attention is limited to trucks hauling heavy or dense commodities and trucks which either have liftable axles or which may be substitutes for those that do. The exact choice of trucks relies, to some extent, on judgement. The following is an overview of the trucks selected:

- Configurations:
  - straight trucks with three or more axles, including those with liftable axles, and those with tandem-steer axles;
  - straight trucks pulling trailers;
  - tractor-semitrailers conforming to the local weight and dimension regulations of each province, with up to nine axles (Ontario only);
  - local double-trailer combinations (A- and B-trains);
  - RTAC tractor-semitrailers, B-trains, and C-trains.

- Configurations excluded as their use remains unaffected by the policy changes considered here and as they do not represent a viable alternative to any of the liftable-axle trucks considered:
  - straight trucks with two axles;
  - RTAC A-trains;
  - long combination vehicles (those operating in Quebec under permit, as these are used to haul low-density freight).

- Body styles:
  - van
  - refrigerated van (or "reefer")
  - flatdeck (or "flat")
  - tank
  - dump

- hopper
- log

The body styles excluded are too numerous to list. They include such obvious categories as low-beds, floats, cement mixers, garbage trucks, container chassis, and a long list of others. They also include some categories such as stake and rack that are sufficiently close to a body style included that their absence is not important (e.g., stake and rack trucking costs probably lie somewhere between "van" and "flatdeck" trucking costs).

Throughout the report, the following symbols are used to represent vehicle configurations, where "x" represents the total number of axles and "y" represents the number of liftable axles:

Tx	-	straight truck
Tx,yL	-	straight truck with y liftable axles
Tx-x	-	straight truck plus trailer
Tx-x,yL	-	straight truck plus trailer, with y liftable axles
x-Sx	-	tractor semitrailer
x-Sx,yL	-	tractor-semitrailer, with y liftable axles
x-Sx-x	-	A-train double (tractor, semitrailer, converter dolly, second semitrailer)
x-Sx-Sx	-	B-train double (tractor and two semitrailers)
x-Sx=x	-	C-train double (double drawbar dolly, or "B-dolly" between the two semitrailers)

"RTAC," as in "RTAC 3-S3," identifies configurations complying with RTAC regulations, that is, those regulations agreed to by all provinces and territories in a 1988 Memorandum of Understanding. The special case of tandem-steer straight trucks is included because this might be a viable alternative under some of the scenarios considered. Currently it is used only in special situations such as trucks delivering heavy construction materials. Some configurations, such as the 3-S4,2L seen in Quebec, have been omitted as the permits under which they operated are no longer being issued; there is no point including them in this analysis.

Gross vehicle weights are calculated under maximum and high-axle-load assumptions. The maximum axle loads, and corresponding GVWs, are not common. It is rare that just the right circumstances, particularly axle-load distributions, allow such possibilities. The inclusion of these maxima here is not important from the perspective of capturing the freight costs of a large number of trucks. Rather, their inclusion represents a boundary line and, hence, provides a more precise comparison of costs between one regulatory scenario and another.

High-axle-load configurations are more realistic in terms of the representation of actual trucks on the road – at least those hauling heavy, dense commodities. The actual values for maximum and high axle loads are given in Appendix A.

Not all real-world possibilities are considered – for example, a 3-S4,2L with a tandem in the middle of two liftable axles is not considered. However, while the possibilities that have been ignored may be important from the perspective of evaluating a truck's interaction with the infrastructure (stability, pavements, geometrics, bridges), they are not critical in an analysis of differences in truck costs – at least, not to the extent costs can be measured here. For example, the operating costs of a T4-3,1L are similar enough to a T3-4 to allow one of these configurations to be ignored.

The RTAC A-train has been omitted because it has a 16-tonne cap on the weight of the rear trailer, which precludes its use for hauling heavy commodities. At the extreme, the rear pup weighs-out with freight denser than 11.7 lbs/ft^3 – well below any freight now hauled on multi-axle semitrailers in Eastern Canada. The RTAC C-train is included at 58.5 tonnes, even though this regulation has not been implemented (current RTAC regulations hold it to 53.5 tonnes). There have been discussions, however, on the possibility of amending RTAC regulations such that the C-train would be allowed a GVW of 58.5 tonnes with no cap on the rear pup. The weight of the rear pup would still be limited, however, to less than the weight of the lead.

The scope of the work, in terms of configurations, is shown on Tables 3.1 through 3.5. Tables 3.2 to 3.4 only show those configurations where GVWs change from the base case in Table 3.1 – that is, only those with liftable axles. Other points to note are:

1/ It is assumed that non-RTAC trucks operate with current *local* axle-load and spacing regulations;

2/ For inter-jurisdictional movements, the "lowest-common-denominator" combination is used; and

3/ New Brunswick configurations are used to represent Atlantic Canada (e.g., the 56.5 t "local" B-train is used, even though Nova Scotia has only allowed this configuration at 50.0 t; or the New Brunswick axle weights are used instead of the somewhat higher ones in Nova Scotia, where tolerances are allowed).

The Scenario #5 trucks on Table 3.5 are identical to current trucks with only one liftable axle shown on Table 3.1.

To understand how the information on Tables 3.1 to 3.5 is compiled, consider the 3-S3 in Quebec. This has been selected for the example because of the large difference between its maximum and high GVW.

Table 3.1/ Scenario#1 Trucks: GVW – GVW (tonnes) under current regulations

		Maximum Axle Loads			High Axle Loads		
	Configurations	Ontario	Quebec	Atlantic	Ontario	Quebec	Atlantic
1	T3	27.8	28.5	26.0	24.9	25.0	24.0
2	T4,1L	37.3	x	x	34.9	x	x
3	T4 (twin steer)	37.1	37.5	x	33.9	34.0	x
4	T3-2	47.0	48.5	44.0	42.9	44.0	42.0
5	T3-3	55.6	57.5	53.1	53.0	53.0	51.0
6	T3-4	62.9	57.5	56.5	61.7	57.5	56.5
7	T4-4,1L	63.5	x	x	63.5	x	x
8	3-S2	45.2	47.0	42.0	42.0	42.0	40.0
9	3-S3	54.5	57.0	51.0	47.3	48.0	47.0
10	3-S3,1L	54.5	57.0	51.0	52.0	52.0	49.0
11	3-S4	61.7	x	x	60.1	x	x
12	3-S4,1L	61.7	55.5	x	57.3	55.5	x
13	3-S4,2L	61.7	x	x	61.5	x	x
14	3-S5,1L	63.5	x	x	61.5	x	x
15	3-S5,2L	63.5	x	x	61.5	x	x
16	3-S6,1L	63.5	x	x	61.5	x	x
17	3-S6,2L	63.5	x	x	61.5	x	x
18	3-S3-S2	63.5	59.0	56.5	61.5	59.0	56.5
19	3-S3-S2,1L	63.5	59.0	x	61.5	59.0	x
20	3-S2-3	63.5	57.5	50.0	61.5	57.5	50.0
21	RTAC 3-S3	46.5	46.5	47.5	45.0	45.0	45.0
22	RTAC 3-S2-S2	56.5	56.5	56.5	56.0	56.0	56.0
23	RTAC 3-S3-S2	62.5	62.5	62.5	62.0	62.0	62.0
24	RTAC 3-S2=3	58.5	58.5	58.5	58.5	58.5	58.5

Table 3.2/ Scenario #2 Trucks: GVW – GVW (tonnes) with liftable axles at 8.0 t

		Maximum Axle Loads			High Axle Loads		
	Configurations	Ontario	Quebec	Atlantic	Ontario	Quebec	Atlantic
2	T4,1L	36.1	x	x	32.9	x	x
7	T4-4,1L	63.5	x	x	63.5	x	x
10	3-S3,1L	53.2	55.0	50.0	50.0	50.0	48. 0
12	3-S4,1L	61.7	55.5	x	55.3	54.0	x
13	3-S4,2L	61.2	x	x	58.0	x	x
14	3-S5,1L	63.5	x	x	61.5	x	x
15	3-S5,2L	63.5	x	x	61.5	x	x
16	3-S6,1L	63.5	x	x	61.5	x	x
17	3-S6,2L	63.5	x	x	61.5	x	x
19	3-S3-S2,1L	63.5	59.0	x	61.5	59.0	x

Table 3.3/ Scenario #3 Trucks: GVW – GVW (tonnes) with liftable axles at 6.0 t

		Maximum Axle Loads			High Axle Loads		
	Configurations	Ontario	Quebec	Atlantic	Atlantic	Quebec	Atlantic
2	T4,1L	34.1	x	x	30.9	x	x
7	T4-4,1L	63.5	x	x	63.5	x	x
10	3-S3,1L	51.2	53.0	48.0	48.0	48.0	46.0
12	3-S4,1L	60.7	55.5	x	53.3	52.0	x
13	3-S4,2L	57.2	x	x	54.0	x	x
14	3-S5,1L	63.5	x	x	61.5	x	x
15	3-S5,2L	63.5	x	x	59.3	x	x
16	3-S6,1L	63.5	x	x	61.5	x	x
17	3-S6,2L	63.5	x	x	61.5	x	x
19	3-S3-S2,1L	63.5	59.0	x	61.5	59.0	x

Table 3.4/ Scenario #4 Trucks: GVW – GVW (tonnes) no liftable axles

		Maximum Axle Loads			High Axle Loads		
	Configurations	Ontario	Quebec	Atlantic	Ontario	Quebec	Atlantic
2	T4,1L	27.8	x	x	24.9	x	x
7	T4-4,1L	62.9	x	x	61.7	x	x
10	3-S3,1L	45.2	47.0	42. 0	42.0	42.0	40. 0
12	3-S4,1L	54.5	55.5	x	47.3	46.0	x
13	3-S4,2L	45.2	x	x	42.0	x	x
14	3-S5,1L	61.7	x	x	60.1	x	x
15	3-S5,2L	54.5	x	x	47.3	x	x
16	3-S6,1L	63.5	x	x	61.5	x	x
17	3-S6,2L	61.7	x	x	60.1	x	x
19	3-S3-S2,1L	61.7	59.0	x	60.1	59.0	x

Table 3.5/ Scenario #5 Trucks: GVW – GVW (tonnes) one liftable axle, at current limits, per truck

		Maximum Axle Loads			High Axle Loads		
	Configurations	Ontario	Quebec	Atlantic	Ontario	Quebec	Atlantic
2	T4,1L	37.3	x	x	34.9	x	x
7	T4-4,1L	63.5	x	x	63.5	x	x
10	3-S3,1L	54.5	57.0	51.0	52.0	52.0	49.0
12	3-S4,1L	61.7	55.5	x	57.3	55.0	x
14	3-S5,1L	63.5	x	x	61.5	x	x
16	3-S6,1L	63.5	x	x	61.5	x	x
19	3-S3-S2,1L	63.5	59.0	x	61.5	59.0	x

	Maximum axle loads (tonnes)	High axle loads (tonnes)
Steering	7.0	5.0
Drive tandem	20.0	18.0
Tridem	30.0	23.0
	57.0	46.0

The maximum front-axle steering load in Quebec is 8.5 tonnes; however, 7 tonnes is considered the practical maximum for tractor-semitrailers. The maximum tandem-axle load in Quebec is 20 tonnes and the maximum tridem-axle load is 30 tonnes. The sum of these loads is the 57 tonne GVW shown. While this tractor-semitrailer, with its maximum axle loads, may exist, it is not common. First, front-axle loads of 5 tonnes are more typical, particularly with the usual front-axle setbacks, fifth wheel offsets, and wheelbases. Second, loads of 20 tonnes on drive tandems are only possible with a spread of greater than 2.4 metres (94"). Such a tractor is extremely rare, if not unknown. The more common drive-tandem spread is between 1.22 to 1.52 metres. At 1.52 metres (60"), a tandem in Quebec is allowed a load of 18.0 tonnes – barring some exceptions made in the case of trucks hauling wood products. Third, considering the tridem, only those with a spread of more than 4.8 metres (189") are allowed a load of 30 tonnes. More commonly, wide-spread tridems are in the range of 3.66 metres (72" + 72") which are allowed loads of 25 tonnes. Together, these high axle loads sum to 48.0 tonnes, which is the GVW shown under the high assumptions on Table 3.1.

A more complex example, the Ontario 3-S4,2L, is shown in the following extract from Tables 3.1 to 3.4:

	Table 3.1		**Table 3.2**		**Table 3.3**		**Table 3.4**	
	Max.	High	Max.	High	Max.	High	Max.	High
Steering axle	7.0	5.0	7.0	5.0	7.0	5.0	7.0	5.0
Tandems	19.1	17.9	19.1	17.9	19.1	17.9	19.1	17.9
Liftable axle	10.0	10.0	8.0	8.0	6.0	6.0	0.0	0.0
Liftable axle	10.0	10.0	8.0	8.0	6.0	6.0	0.0	0.0
Tandems	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1
Sum	65.2	62.0	61.2	58.0	57.2	54.0	45.2	42.0
Max. GVW	61.7	60.1	61.7	60.1	61.7	60.1	45.5	43.0
GVW	61.7	60.1	61.2	58.0	57.2	54.0	45.2	42.0

Points to note about this information are:

1/ While it is possible to have higher front-axle loads, 7 tonnes has been selected as the maximum steering-axle for most tractors;

2/ Drive tandems alternate between 19.1 tonnes, the maximum allowed for tandems with a spread of at least 1.8 metres, and 17.9 tonnes, the maximum for what is usually the widest-spread tandem on a tractor (1.52 m or 60");

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3/ Both the maximum and high axle loads for the tandems on the trailer are shown at 19.1 tonnes as this, with a spread of 1.83 metres (72") is quite common (i.e., there is no point in assuming any difference between "maximum" and "high" axle loads);

4/ The "max. GVW" shown is directly from the tables controlling GVWs in Ontario – the key variable here is front-axle load as all the necessary axle spacings have been assumed; and

5/ Under the fourth regulatory scenario, it is to be noted that the "max. GVW" in effect treats the configuration as if it were a 3-S2, as the lift axles are ignored.

In comparing the information shown in Tables 3.1 through 3.5, note that GVWs do not necessarily fall as a direct function of the load allowed on liftable axles. For example, on Table 3.1 the T4-4,1L in Ontario is shown with a GVW of 63.5 tonnes under both assumptions about axle loads. On Tables 3.2 and 3.3, it is also shown with a GVW of 63.5 tonnes under both axle load assumptions, even though liftable axle loads are held in Scenario #2 (Table 3.2) to 8.0 tonnes and in Scenario #3 (Table 3.3) to 6 tonnes. The calculations for this configuration are as follows:

	Table 3.1		**Table 3.2**		**Table 3.3**	
	Max.	High	Max.	High	Max.	High
Steering-axle	9.0	7.0	9.0	7.0	9.0	7.0
Liftable axle	10.0	10.0	8.0	8.0	6.0	6.0
Tandems	19.1	17.9	19.1	17.9	19.1	17.9
Tandems	19.1	19.1	19.1	19.1	19.1	19.1
Tandems	19.1	19.1	19.1	19.1	19.1	19.1
	====	====	====	====	====	====
Sum	76.3	73.1	74.3	71.1	72.3	69.1
Max. GVW	63.5	63.5	63.f5	63.5	63.5	63.5

In this, and several other cases, there is "excess axle-load capacity." Because of this, some trucks shown on Tables 3.1 to 3.5 remain unaffected by either the "max/high" axle load assumptions or the regulatory scenario. When costs are developed for these trucks (discussed in Section 9), they will also remain unaffected by these assumptions and/or scenarios. Without, then, undertaking any of the cost analysis, one conclusion

already can be made: a policy of simply reducing allowable liftable-axle load limits will not necessarily have an impact on all truck configurations, in particular, those which already have excess axle-load capacity. That is, carriers using these configurations will still haul the same payloads and will have no incentive to switch to other, fixed-axle configurations. Of course, in the real world, things are a bit more complex than these statements suggest. Excess axle-load capacity, while not necessarily giving a carrier a payload advantage, does give a carrier more latitude in placing the load on the truck. This is sometimes important for large, fixed cargoes such as pallets of bricks or heavy steel coils.

There is one final point about the information shown in the tables. In Table 3.1, a 3-S4- – that is, a 4-axle semitrailer with no liftable axles – is shown in Ontario. Later information presented in Section 12 will suggest that such configurations carry over 3% of all freight (measured by tonnes) in the province. There is some question, however, as to whether or not such a vehicle actually exists. Information from road-side surveys suggests it does, but other sources suggest it is highly unlikely that such a semitrailer would be able to work properly with four fixed axles and, further, that there is an accuracy problem with data from road-side surveys. Casual inspection by summer students cannot always reveal whether or not the axles on a vehicle are liftable or not, particularly where air suspensions are used for all axles. This debate is immaterial here. To be on the safe side, a 3-S4 is included so that the operating costs of such a vehicle may be compared to other vehicles.

4/ PAYLOADS

There are several ways of calculating payloads: the "averages" shown in Trimac's costing procedures; a survey of carriers to develop new averages (by commodity, by truck type, etc.); or calculated payloads given information on gross and tare weights. The third of these three possibilities is used here as the Trimac figures are too general and the possibility of a suitable comprehensive survey of carriers is not within the scope of the research.

Tare weights vary considerably from one situation to another depending on:

- the age and manufacturer of the equipment;
- the type of equipment on trucks (sleepers, extended range fuel tanks, loading cranes of up to 4.5 tonnes used to haul logs or construction materials, etc.);
- the material used (steel, FRP, aluminum);
- the construction method (e.g., double-walled stainless steel tanks for hauling milk versus single-walled aluminum tanks for other liquids, etc.).

Appendix C outlines information on tare weights obtained from a range of sources. Table 4.1 provides a summary.

To convert the information on GVWs and tare weights to payloads, the maximum/high axle loads and the maximum/minimum tare weights result in four payload possibilities:

Axle loads:	Max.	Max.	High	High
Tare weight:	Max.	Min.	Max.	Min
	===	===	====	====
	1	2	3	4

Only two of these possibilities are used. The second, with maximum axle loads and minimum tare weights, gives the highest possible payload. The third, with high (or typical) axle loads and maximum tare weights, gives the lowest of the four possible heavy payloads. These two possibilities represent the upper and lower bounds for heavy payloads in the cost analysis. In actual practice, the payloads calculated under #3 are fairly common when allowance is made for a wide range of factors not captured in the costing: under-loading to allow for load shifts; under-loading to allow for ice, snow, or moisture build-up; under-loading to leave a margin of error at weigh scales; under-loading because of non-optimal load sizes; etc.

Table 4.1/ Tare Weights (tonnes)

Maximum Axle Loads

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
1	T3	9.3	11.8	8.6	10.2	10.0	10.0	9.5
2	T4,1L	10.6	13.1	9.9	11.5	11.3	11.3	10.8
3	T4 (twin steer)	10.6	13.1	9.9	11.5	11.3	11.3	10.8
4	T3-2	14.5	20.9	13.6	16.1	15.4	15.4	14.5
5	T3-3	15.7	22.2	14.7	16.3	18.3	18.3	15.9
6	T3-4	16.9	23.5	16.0	17.6	19.6	19.6	17.4
7	T4-4,1L	18.2	24.8	17.3	18.9	20.8	20.8	18.4
8	3-S2	15.9	20.0	15.0	15.2	15.9	15.9	15.2
9	3-S3	17.0	21.3	16.3	17.7	16.8	16.8	16.6
10	3-S3,1L	17.0	21.3	16.3	17.7	16.8	16.8	16.6
11	3-S4	18.1	22.7	17.7	18.8	18.6	19.7	17.9
12	3-S4,1L	18.1	22.7	17.7	18.8	18.6	19.7	17.9
13	3-S4,2L	18.1	22.7	17.7	18.8	18.6	19.7	17.9
14	3-S5,1L	19.4	24.0	19.0	20.1	19.8	20.9	19.2
15	3-S5,2L	19.4	24.0	19.0	20.1	19.8	20.9	19.2
16	3-S6,1L	20.7	25.2	20.2	21.4	21.1	22.2	20.5
17	3-S6,2L	20.7	25.2	20.2	21.4	21.1	22.2	20.5
18	3-S3-S2	21.1	29.0	20.6	21.5	23.3	23.3	20.9
19	3-S3-S2,1L	21.1	29.0	20.6	21.5	23.3	23.3	20.9
20	3-S2-3	21.8	29.5	21.3	23.1	22.2	22.2	21.3
21	RTAC 3-S3	17.0	21.3	16.3	17.7	16.8	16.8	16.6
22	RTAC 3-S2-S2	20.0	27.7	19.5	21.3	20.4	20.4	19.5
23	RTAC 3-S3-S2	21.1	29.0	20.6	21.5	23.3	23.3	20.9
24	RTAC 3-S2=3	21.3	29.0	20.9	22.7	21.8	21.8	20.9

High Axle Loads

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
1	T3	8.8	10.9	8.2	9.1	8.7	9.1	8.6
2	T4,1L	9.8	11.9	9.2	10.1	9.7	10.1	9.6
3	T4 (twin steer)	9.9	12.0	9.3	10.2	9.8	10.2	9.7
4	T3-2	13.4	17.7	12.2	14.1	13.7	14.1	13.4
5	T3-3	14.5	19.1	13.4	14.7	14.7	15.1	14.7
6	T3-4	15.6	20.1	14.5	15.7	15.8	16.2	15.8
7	T4-4,1L	16.6	21.1	15.5	16.7	16.8	17.2	16.8
8	3-S2	13.8	17.0	13.2	13.6	14.3	13.2	13.8
9	3-S3	15.0	18.4	14.5	16.1	15.2	15.2	15.2
10	3-S3,1L	15.0	18.4	14.5	16.1	15.2	15.2	15.2
11	3-S4	16.1	19.7	15.9	17.2	16.1	17.9	16.6
12	3-S4,1L	16.1	19.7	15.9	17.2	16.1	17.9	16.6
13	3-S4,2L	16.1	19.7	15.9	17.2	16.1	17.9	16.6
14	3-S5,1L	17.1	20.7	16.9	18.2	17.1	18.9	17.6
15	3-S5,2L	17.1	20.7	16.9	18.2	17.1	18.9	17.6
16	3-S6,1L	18.1	21.7	17.9	19.2	18.1	19.9	18.6
17	3-S6,2L	18.1	21.7	17.9	19.2	18.1	19.9	18.6
18	3-S3-S2	18.6	23.4	17.7	19.0	19.4	19.4	19.3
19	3-S3-S2,1L	18.6	23.4	17.7	19.0	19.4	19.4	19.3
20	3-S2-3	19.3	23.8	18.4	20.2	20.2	20.2	19.7
21	RTAC 3-S3	15.0	18.4	14.5	16.1	15.2	15.2	15.2
22	RTAC 3-S2-S2	17.5	22.0	16.6	18.4	18.4	18.4	17.9
23	RTAC 3-S3-S2	18.6	23.4	17.7	19.0	19.4	19.4	19.3
24	RTAC 3-S2=3	18.8	23.4	17.9	19.7	19.7	19.7	19.3

5/ GENERAL COSTING METHODOLOGY

The development of costs for different configurations and different regulatory scenarios is accomplished with one program corresponding to each of seven truck body styles. The programs develop 106 costs per tonne-kilometre – 53 configurations in the three regions and the maximum and high payload. The total number of calculated costs is 424 (4 scenarios x 106), although there is much duplication as trucks with no liftable axles retain their GVWs and payloads from one scenario to another and, hence, show the same costs per tonne-kilometre under each scenario. The costs for Scenario #5 (trucks with only one liftable axle) are contained in Scenario #1. Gross vehicle weights and payloads, corresponding to each of the regulatory scenarios, are developed as described in Sections 3 and 4.

At the start of the program, the user can specify the following:

- assumptions about the effect of heavy axles on maintenance and tire costs
- assumptions about the effect of axle spreads on maintenance and tire costs
- trip length
- annual hours of utilization
- regulatory scenario (1 to 4) (#5 is contained in #1)
- backhaul (yes, no)
- trip speed
- load/unload rate
- non-trip distance (i.e., driving distance not directly related to hauling freight)
- fuel equation coefficients (Appendix D)
- overheads
- cost of capital

The model then calculates the following values:

- trip time
- annual trips
- annual tonnes
- annual kilometres
- annual tonne-kilometres

Factor prices, described in Section 6, are as follows:

- labour rates (Trimac)
- equipment prices (Appendix E)
- registration fees (Appendix F)
- depreciation rates (Trimac)
- fuel prices per litre (Trimac)
- maintenance costs (developed from Trimac, Appendix G)

- tire costs (developed from Trimac, Appendix H)
- "transport" costs (developed from Trimac; "transport" is an allowance for the equipment that accompanies a truck, Appendix I)
- cleaning costs (developed from Trimac, Appendix J)
- overheads (Trimac's 17% of total, unless user specifies otherwise)
- cost of capital (20% pre-tax, unless user specifies otherwise)

These factor prices are combined with estimates of productivity to produce trucking costs. Most of the productivity factors – the key ones – are specified at the beginning of the program by the user. They are discussed in Section 7 below and include the following:

- load/unload rates (Trimac's 30.27 or 32.72 tonnes per hour)
- annual utilization (annual hours of operation)
- fuel consumption (Section 7.3 and Appendix D)
- the effect of axle spread and load on maintenance and tire costs

Actual costs are calculated as follows:

- sum annual fixed costs (depreciation + registration + transport)
- sum annual variable costs (total distance times per-km costs)
- sum annual load/unload costs (load/unload hours times hourly labour rate)
- calculate overheads (17% of total, or 23.3% of truck operating costs)
- calculate return on investment ("profit") as a percent of equipment prices
- divide total annual costs (fixed, variable, load/unload, overheads, capital) by total annual output measures (tonnes, tonne-kilometres, hours, kilometres)

For each configuration, two costs are developed: one corresponding to the maximum payload and one to the high payload. More costs could have been developed if factor prices also were given as a range of values. However, this has not been done and in only three cases do factor prices vary for a particular truck configuration: fuel costs, registration fees, and tire and maintenance costs. In all three cases, the factor prices are dependent on GVW and, hence, have to vary for the "max/high" payloads. Fuel consumption is a function of weight (Section 7.3). Registration fees are also a function of GVW (Appendix F). Finally, maintenance and tire costs depend on the axle-spreads and axle loads; these vary from the maximum to the high axle-load scenarios. Further information on maintenance and tire costs is contained in Section 6.5 and 6.6 (basic factor prices), Section 7.4 (the relationship between spread and costs), and Appendices G and H (analysis of Trimac's data).

A sample printout of the program and a comparison with Trimac costs is described in Appendix K.

6/ FACTOR PRICES

6.1/ Depreciation

Depreciation is calculated in the costing model on the basis of the rates used by Trimac: 12% for trailers, 15.8% for power unit – times the purchase price of equipment. Ideally, equipment prices should reflect mid-1988 prices to be consistent with other factor prices. However, the prices collected from truck and trailer manufacturers reflect those in effect in the winter of 1989/90. Details are provided in Appendix E.

6.2/ Registration

Registration taxes for the GVWs shown on Tables 3.1 to 3.5 are listed in Appendix F. Most trucks operating between jurisdictions register under CAVR (the Canadian Agreement on Vehicle Registration) or the IRP (International Registration Plan). In either case, registration fees are prorated on the basis of distance driven. For example, a truck with 50% of its total distance in Ontario would pay 50% of the applicable registration fee. This subtlety is omitted here as the effect of assuming an average registration fee between the relevant jurisdictions produces an estimate of costs that is just as reliable.

6.3/ Labour

Trimac's labour rates for bulk trucking are used for all configurations. Costs for driving time are based on the mileage rate, costs for load/unload time are based on the hourly rate.

	Ontario	Quebec	Atlantic
Base hourly rate	$14.39	$12.76	$10.74
Base distance rate (per km)			
single-trailers (or truck)	$ 0.1993	$ 0.1903	$ 0.1443
double-trailers	$ 0.2068	$ 0.1953	$ 0.1486
Wage burden	26.0%	29.0%	21.3%

6.4/ Fuel

Trimac fuel prices per litre are used but specific fuel-consumption rate equations are developed to convert these into costs. The fuel consumption rates are described in Section 7.3 and discussed in detail in Appendix D.

	Ontario	Quebec	Atlantic
Fuel price ($/L)	$ 0.4724	$ 0.5530	$ 0.4314

6.5/ Maintenance

Maintenance costs, based on Trimac and discussed more fully in Appendix G, are shown in Table 6.1. "Small" and "large" indicate tractors used with less than 7-axle or 7-or-more-axle configurations. This corresponds to Trimac's tractors used in 3-S2's versus those used in trains. The effect is to make maintenance cost higher for tractors hauling at the highest GVWs, which is consistent with actual experience. Two critical aspects of maintenance costs – the effect of wide-spread axle groups and the effect of axle loads – are discussed in Section 7.4. The impact of axle spreads and axle loads is to increase the relevant costs for some configurations above the values shown in Table 6.1.

Table 6.1/ Maintenance Costs

Maintenance Costs per Kilometre (cents)

	Ontario	Quebec	New Brunswick
3-axle truck			
van, reefer, flat	12.6	12.1	13.9
tank, dump, hopper, log	14.7	14.7	14.4
Small tractor	12.1	12.2	11.6
Large tractor	14.3	14.5	13.9
2-axle trailer			
van, reefer, flat	5.7	6.0	5.1
tank, dump, hopper, log	7.7	7.7	6.3
Additional Axles	0.5	0.5	0.5

Table 6.2/ Tire Costs

Tire Costs per Kilometre (cents)

	Ontario	Quebec	New Brunswick
2-axle truck	4.0	4.0	3.9
Tractor	2.9	2.8	2.5
2-axle trailer	2.9	2.9	2.1
Additional Axles	0.2	0.2	0.2
Liftable (empty backhaul)	0.1	0.1	0.1

6.6/ Tires

Tire costs, based on Trimac (Appendix H), are shown in Table 6.2. It is assumed that tire costs for liftable axles are at one-half the level of fixed axles when there is an empty backhaul. The effect of wide-spread axle groups and the effect of axle loads are discussed in Section 7.4; their impact is to raise the costs shown for some configurations.

6.7/ Other Equipment

"Transport" costs, in Trimac's lexicon means "a miscellaneous category to reflect all those factors that may be attributed to extra equipment that are not normally viewed as part of a vehicle's standard configuration. This may represent special pumps, hoses, safety equipment, dunnage, small tools, chains, tarping, heaters, or refrigeration equipment." In a footnote, Trimac notes that the last three items – tarping, heaters, and refrigeration – are not included "for this analysis."

Although Trimac includes these "transport" costs as a variable cost associated either with the tractor or the trailer – that is, a cost per kilometre, their actual specification in Trimac's procedures is as an annual fixed cost. That is, they are invariant with distance driven. This is a realistic assumption and, accordingly, they are treated here as invariant with distance. This means that for calculation purposes they are lumped in with other annual costs (registration, depreciation).

The values for "transport" or, as they are referred to here, "other equipment" costs are shown in Table 6.3 and a more detailed explanation of their origin is given in Appendix I.

Table 6.3/ Other Equipment Costs

	Annual Costs (dollars)		
	Ontario	Quebec	New Brunswick
Truck	489	380	434
Tractor	1954	2389	2171
Trailer - van, flatdeck	1629	1520	1086
- all other	1846	2497	2497

6.8/ Cleaning

Cleaning costs are shown in Table 6.4. They are based on Trimac (Appendix J).

Table 6.4/ Cleaning Costs

	Cleaning Costs per Kilometre (cents)		
	Ontario	Quebec	New Brunswick
Truck - van, reefer	0.4	0.4	0.4
- tank	1.1	0.9	0.8
- other	0.0	0.0	0.0
Tractor	0.4	0.4	0.3
Single trailer			
- van, reefer	1.9	1.8	0.6
- tank	2.1	2.1	0.5
- other	0.0	0.0	0.0
Double trailer			
- van, reefer	2.0	1.9	0.8
- tank	2.2	2.2	1.0
- other	0.0	0.0	0.0

6.9/ Overheads

Trimac's overheads amount to 17% of total costs. This value has been used here – that is, 23.39% of truck operating costs. (100-27 = 73, and 17/73 = 23.39%) This is an allowance for administration, interest, and insurance.

6.10/ Profit

Trimac's profit is 10% of total costs. For here, in an effort to make the results more sensitive to differences in equipment prices, the return on investment is calculated as 20% (pre-tax cost of capital) of the purchase price of equipment. The model allows alternative costs of capital for specific applications.

7/ PRODUCTIVITY

7.1/ Load/Unload Rates

Load/unload rates used in the costing model are the same as those used by Trimac for bulk freight: 30.27 tonnes per hour for payloads less than 22.7 tonnes and 32.72 tonnes per hour for larger payloads. Other values can be added to the model for specific applications. This rate has to account for all time spent at the origin and destination while the driver is waiting to be loaded or unloaded and while the actual process of loading and unloading occurs. It varies considerably from one situation to another, making it difficult to develop a realistic average for all trucking activity.

The following three examples of a van in Ontario show the effect of these load/unload rates on the costing.

	T3	3-S2	3-S3-S2
High axle load payload (t)	15.6	26.1	40.4
Load/unload rate (t/hr)	30.27	32.72	32.72
Load/unload time (hr)	0.52	0.80	1.24
Load/unload cost ($/t)	0.60	0.55	0.55

7.2/ Annual Utilization

The main determinant of equipment utilization in the costing model is the assumed annual hours of operation. In Trimac's procedures, it is annual kilometres driven. The default value is 2000 hours, although any figure can be specified for particular applications. From this variable, all else follows: number of trips, number of tonnes, total kilometres, etc. A secondary variable, of much less significance, is the allowance for kilometres driven over-and-above trip kilometres. This accounts for such things as moving equipment to maintenance facilities, positioning equipment (e.g., between the destination of one trip and the beginning of another trip), and drivers who drive to and from loading points. This non-trip distance varies considerably from one situation to another and, in lieu of any empirical data, the following values are used:

- vans 5%
- reefer 5%
- flat 7%
- tank 5%
- dump 10%
- hopper 10%
- log 10%

The model allows users to specify their own value for this variable. As it is likely a function of trip distance – the longer the trip, the fewer the non-trip kilometres as a

percent of total, specific applications of the costing program should increase or decrease the above values accordingly.

7.3/ Fuel Consumption

Although most factor prices and productivity assumptions are developed from Trimac information, fuel consumption is one variable for which Trimac data are insufficient. First, it is not clear how the Trimac data are developed nor how accurately they reflect the relationship between vehicle weight and fuel consumption. Second, in the analysis developed here, there is a far broader range of configurations considered and the issue of fuel consumption, as a function of GVW, is important.

The latest information from Ontario's "Drive$ave/Trucksave" program, for 318 actual highway trips, suggests fuel consumption rates are proportional to GVW, as given in Appendix D. These are above average rates in that the data were collected from a competition in which the drivers were attempting to keep fuel consumption low.

The values were developed on the basis of actual highway driving tests. Therefore, the costing model does not reflect "city" or "stop and go" driving or, for that matter, such special situations as gravel road or off-road driving. To this extent, then, fuel costs developed here under-represent actual costs of many trucking hauls. Second, the statistical tests used to develop these equations suggest there are many factors besides GVW influencing fuel consumption. No data can be developed on these other factors and, for here, this is not important. That is, the only variable that the policy under consideration affects is the gross vehicle weight in as much as a change in the policy on liftable axles might convince some carriers to use alternative equipment. So, while such issues as the use of aerodynamic devices, speed, engine size, and a host of others are important to fuel consumption, the assumption here is that these other factors are held constant in the analysis.

In the model, the two coefficients shown in the above equations are treated as variables; that is, they can be specified at the start of the program for specific applications. For example, if someone has precise data on fuel consumption for a logging truck in an off-road application, the numbers can be punched in. A final point to note about the calculation of fuel consumption is that the model "recognizes" empty backhauls. In these cases, GVW – the independent variable – is reduced by one-half the payload, the effect being an improvement in fuel consumption and, hence, a lower hauling cost.

7.4/ Maintenance and Tire Costs

Equipment manufacturers and carriers suggest that both maintenance costs and tire costs vary as a function of axle spread and as a function of axle load. No credible data could be found on this subject. In lieu of this, several assumptions have been built into the model.

Axle spreads: maintenance and tire costs are assumed to be as shown in Tables 6.1 and 6.2 except as modified by the following:

Normal spreads (less than 1.79 m or 70")	–	Trimac
Wide-spread (1.8 m to 2.0 m, or 71" - 79")	–	Trimac + 10%
Very wide-spread (over 2.0 m, or 79")	–	Trimac + 20%

These factors (0%, 10%, 20%) can be changed in the model to suit particular applications. Because this aspect of maintenance and tire cost is complex, Table 7.1 has been prepared showing which vehicles are affected. The figures in the table can be read as follows:

0 + 10 + 20 — a power unit with normal axle spreads, a trailer with wide-spread axles, and a second trailer with very wide-spread axles. This could be, for example, a 3-S2-3 where the tractor has typical drive tandems with a spread of 1.22 to 1.52 metres (48" - 60"), a lead trailer with 1.83 metre (72") tandems, and a second pup trailer (and an A-converter dolly) with an unusual 2.40 metre (94") tandem.

At several places in Table 7.1 (and in the model), strict adherence to the above procedures has not been followed. Following strictly the axle loads and assumed spreads used in Table A.1 sometimes results in configurations with such a large excess axle capacity that it is hard to imagine anyone actually using such a vehicle. In all such cases, these are the maximum-axle load assumptions for A- or B-trains. These have been indicated with an asterisk in Table 7.1. In the five cases shown, the configuration has been given "very wide-spread" axle groups in the program described in Appendix A. Strictly, this demands maintenance costs of plus 20%. For here, these have been reduced to plus 10%.

Axle loads: although precise boundary lines and impacts are not known, the following values have been built into the model to reflect the impact of axle loads:

	Increase in maintenance and tire costs per kilometre
Axle loads over 8 tonnes	20%
Axle loads over 9 tonnes	30%

These variables (20% and 30%) may be changed by the user. The actual form of the calculation is more complex than as suggested by the above two numbers. Where the activity considered includes empty backhauls, the values (20% and 30%) are cut in half. That is, the effect of heavy axle loads on maintenance and tire costs is assumed to be operative for only half the driving distance. Second, the actual calculation ignores front-steering axles and considers only the average load on all other axles. The algorithm is:

Table 7.1/ Assumptions of Percentage Increase in Maintenance and Tire Costs Versus Axle Spreads, for all Truck Configurations

		Maximum Axle Loads			High Axle Loads		
	Configuration	Ontario	Quebec	Atlantic	Ontario	Quebec	Atlantic
1	T3	10	20	0	0	0	0
2	T4,1L	10			0		
3	T4 (twin steer)	10	20		0	0	
4	T3-2	10+ 0	20+ 0	0+ 0	0+ 0	0+ 0	0+ 0
5	T3-3	10+10	20+20	0+10	0+10	0+10	0+10
6	T3-4	10+10	20+20	0+10	0+10	0+10	0+10
7	T4-4,1L	10+10			0+10		
8	3-S2	10+10	20+20	0+10	0+10	0+10	0+10
9	3-S3	10+20	20+20	0+20	0+10	0+ 0	0+10
10	3-S3,1L	10+10	20+20	0+10	0+10	0+10	0+10
11	3-S4	10+20	20+10		0+20	0+ 0	
12	3-S4,1L	10+20	20+20		0+10	0+ 0	
13	3-S4,2L	10+10			0+10		
14	3-S5,1L	10+20			0+20		
15	3-S5,2L	10+20			0+10		
16	3-S6,1L	10+20			0+10		
17	3-S6,2L	10+20			0+20		
18	3-S3-S2	10+10+10*	10+10+10*	0+10+10*	0+10+10	0+ 0+10	0+10+10
19	3-S3-S2,1L	10+10+10	10+10+10*		0+10+10	0+ 0+10	
20	3-S2-3	10+10+10	10+10+10*	0+10+10	0+10+10	0+10+10	0+10+10
21	RTAC 3-S3	0+ 0	0+ 0	0+ 0	0+ 0	0+ 0	0+ 0
22	RTAC 3-S2-S2	0+ 0+ 0	0+ 0+ 0	0+ 0+ 0	0+ 0+ 0	0+ 0+ 0	0+ 0+ 0
23	RTAC 3-S3-S2	0+ 0+ 0	0+ 0+ 0	0+ 0+ 0	0+ 0+ 0	0+ 0+ 0	0+ 0+ 0
24	RTAC 3-S2=3	0+ 0+ 0	0+ 0+ 0	0+ 0+ 0			

* impact of axle spread reduced from 20% to 10%

If (GVW - 6 t)/(# of non-steering axles) is greater than 8 t, then factor = 1.2; if greater than 9 t, then factor = 1.3

In other words, there is a uniform allowance for six tonnes on the front axle and a requirement that all other axles together must weigh more than either eight or nine tonnes before these axle-load factors become operative.

An example of how all these factors work will make the costing process clearer. Consider the 3-S4,1L and the RTAC 3-S2-S2 in Ontario; the following shows the physical characteristics of these two configurations.

	Ontario 3-S4,1L (van)		Ontario RTAC 3-S3-S2 (van)	
	Max.	High	Max.	High
GVW (t)	61.7	57.3	62.5	62.0
Payload (t)	45.6	39.2	43.9	40.9
Axle loads (t)				
- steering	7.0	5.0	5.5	5.0
- drive tandem	19.1	17.9	17.0	17.0
- trailer				
- lift	10.0	10.0		
- tridem	28.6	24.4	23.0	23.0
- tandem		17.0	17.0	
Axle spreads (m)				
- drive tandem	1.83	1.52	1.22+	1.22+
- lift-to-tridem	2.50	2.50		
- trailer tandems		1.22+	1.22+	
- tridem	2.4+2.4	1.8+1.8	1.5+1.15	1.5+1.5
Load/non-steering axles	9.28	8.55	8.07	8.00

In terms of the effect of axle-spreads, the trailer in the 3-S4,1L, under the maximum axle-load assumption, is subject to the 20% increase in both maintenance and tire costs (the tridem is "very wide spread"). The tractor for the 3-S4,1L under the maximum axle-load assumption and the trailer under the high axle-load assumption are subject to a 10% increase in maintenance and tire costs (they have tandems and/or tridems with spreads over 1.8 metres). The RTAC 3-S3-S2, on the other hand, has no wide-spread axle groups.

In terms of axle loads, the 3-S4,1L under the maximum axle-load assumption has an average of 9.28 tonnes per non-steering axle and, therefore, has its maintenance and tire costs increased by 30%. Under a "no backhaul" scenario, this would be cut in half. The 3-S4,1L under the high axle-load assumptions has an average of 8.55 tonnes per non-steering axle and the 3-S3-S2 has an average of 8.07 tonnes. Both have their

maintenance and tire costs increased by 20%. Only the B-train at 62.0 tonnes, then, has no increase (over the Trimac figures) in its maintenance and tire costs.

The following shows the effect of these calculations on trucking costs in cents/km, using Ontario factor prices at a trip distance of 160 km under the assumption of 2000 operating hours. The first line shows total variable costs (i.e., costs that vary with distance driven), and the next three lines show the components of variable costs that account for the differences among the configurations shown. The 3-S4,1L with no backhaul is included to show the effect of the absence of a backhaul on the maintenance and tire cost assumptions.

	zero		as described above					
			3-S4,1L				3-S3-S2	
	Backhaul		Backhaul		No backhaul		Backhaul	
			Axle Spread and Load Assumption					
Costs	Max.	High	Max.	High	Max.	High	Max.	High
Variable	76.9	75.5	89.7	82.5	80.7	76.3	93.0	85.9
Maintenance	21.0	21.0	23.7	21.6	23.7	21.6	26.2	26.2
Tire	6.2	6.2	7.2	6.9	7.0	6.7	8.9	8.9
Heavy axle load	0.0	0.0	9.2	5.7	4.6	2.8	7.0	0. 0

The first two columns show costs as they would be without the axle-spread/axle-load assumptions. The next four columns show the 3-S4,1L with the axle-spread/axle-load assumptions operating under backhaul and no backhaul situations. The last two columns shown the RTAC B-train by way of comparison. As can be seen, the axle-spread, axle-load assumptions have a fairly pronounced impact on operating costs.

8/ SENSITIVITY ANALYSIS

Variables used in the model are based on data that vary considerably from one situation to another. This section analyzes this variability by presenting numbers developed from a sensitivity analysis. It is performed only for vans in Ontario. Actual values for other trucks and/or regions would be slightly different, but the direction and magnitudes would be similar.

The axle-spread/axle-load assumption and the presence of backhauls are analyzed on Table 8.1. As can be seen in the first and third columns, the disabling of the axle-spread/axle-load assumptions reduces total costs per tonne-kilometre by anywhere from zero to eight percent. These assumptions have their greatest impact where spreads are wide and axle-loads heavy. As shown in the second and fourth columns, the absence of a backhaul raises costs by 65 to 81%, depending on the configuration.

On Table 8.2 the impact of increasing one of seven variables by 10% is shown. The variables are:

1/ trip length - increased by 10% – to 176 km
2/ annual hours - increased by 10% – to 2200 hr
3/ load/unload time - increased by 10% – i.e., 90% of t/hr
4/ trip speed - increased by 10% – to 88 km/hr
5/ non-trip distance - increased by 10% – to 5.5%
6/ cost of capital - increased by 10% – to 22%
7/ overheads - increased by 10% – 25.73%

Annual operating hours is the most important variable (of the seven) in the model, followed closely by load/unload time, trip speed, and trip length.

On Table 8.3 the results of altering a series of variables is shown. "Multi #1" shows the effect of an increase of 10% in all seven of the above variables; "Multi #2" shows the effect of a decrease of 10% in the variables. As the impact of some variables cancels out that of others, the overall impact is small. "Multi #3" and "Multi #4" show the effect of a "high cost" and a "low cost" scenario. The variables under each of these scenarios, and under the "base" case, are as follows:

	Base Case	High Cost	Low Cost
Axle loads (maint. & tire costs)	0,20,30 %	0,30,40 %	0,10,20 %
Axle spreads (maint. & tire costs)	0,10,20 %	0,20,40 %	0,5,10 %
Operating hours	2000	1800	2200
Trip speed	80	70	90
Load/unload rate (t/hr)	30.24/32.70	25	50
Non-trip distance	5 %	10 %	0 %
Fuel consumption (km/L)			
fixed	3.4729	3.0	3.8
variable (GVW)	0.0219	0.02	0.024
Overheads (% of operating)	23.29 %	25 %	20 %
Cost of capital	20 %	25 %	15 %

Table 8.1/ Axle-Spread, Axle-Load Assumptions; Backhauls

		(% change in costs per tne-km) Maximum Axle Load		High Axle Load	
	Configurations	Axle-Spread, Axle-Load Assumption	Empty Backhaul	Axle-Spread, Axle-Load Assumption	Empty Backhaul
1	T3	-7.0%	78.9%	-5.2	81.3
2	T4,1L	-6.7	74.2	-4.9	76.1
3	T4 (twin steer)	-6.6	74.4	-4.8	76.8
4	T3-2	-7.3	71.5	-6.0	74.2
5	T3-3	-7.7	67.7	-6.2	69.4
6	T3-4	-7.5	64.7	-6.2	65.6
7	T4-4,1L	-5.7	65.9	-4.5	66.4
8	3-S2	-7.7	72.6	-4.7	76.9
9	3-S3	-8.1	68.4	-4.1	74.4
10	3-S3,1L	-7.3	68.1	-6.2	70.3
11	3-S4	-8.3	65.5	-7.1	67.0
12	3-S4,1L	-8.2	65.3	-4.8	69.5
13	3-S4,2L	-7.4	65.1	-6.2	66.6
14	3-S5,1L	-6.4	66.2	-1.4	70.9
15	3-S5,2L	-6.3	66.0	-0.7	70.5
16	3-S6,1L	-2.6	69.5	-1.0	71.4
17	3-S6,2L	-2.5	69.3	-1.4	71.4
18	3-S3-S2	-6.7	67.9	-1.2	73.2
19	3-S3-S2,1L	-6.6	67.8	-1.1	73.0
20	3-S2-3	-6.7	68.2	-1.2	73.5
21	RTAC 3-S3	-3.8	73.7	0.0	78.8
22	RTAC 3-S2-S2	-4.4	70.5	-4.5	72.0
23	RTAC 3-S3-S2	-4.3	68.0	0.0	72.6
24	RTAC 3-S2=3	0.0	63.2	0.0	74.5

Table 8.2/ Percentage Change in Costs per tne-km, Given a 10% Increase in Seven Variables, for Maximum Axle Loads

	Configurations	1 Trip length	2 Hours	3 L/U time	4 Trip speed	5 Extra km	6 K cost	7 Over-heads
1	T3	-1.2%	-2.6%	1.5%	-2.0%	0.3%	1.4%	1.6%
2	T4,1L	-1.6	-2.8	1.9	-2.0	0.3	1.5	1.6
3	T4 (twin steer)	-1.6	-3.0	1.9	-2.1	0.3	1.6	1.6
4	T3-2	-1.7	-2.8	2.1	-1.8	0.3	1.4	1.6
5	T3-3	-2.0	-2.9	2.4	-1.8	0.3	1.5	1.6
6	T3-4	-2.2	-3.0	2.6	-1.7	0.3	1.5	1.6
7	T4-4,1L	-2.2	-3.1	2.7	-1.8	0.3	1.6	1.6
8	3-S2	-1.6	-2.9	2.0	-1.9	0.3	1.6	1.6
9	3-S3	-1.9	-2.9	2.4	-1.8	0.3	1.5	1.6
10	3-S3,1L	-1.9	-3.0	2.4	-1.8	0.3	1.5	1.6
11	3-S4	-2.1	-3.0	2.6	-1.8	0.3	1.5	1.6
12	3-S4,1L	-2.1	-3.0	2.6	-1.8	0.3	1.5	1.6
13	3-S4,2L	-2.1	-3.0	2.6	-1.8	0.3	1.5	1.6
14	3-S5,1L	-2.2	-3.1	2.7	-1.8	0.3	1.6	1.6
15	3-S5,2L	-2.2	-3.1	2.7	-1.8	0.3	1.6	1.6
16	3-S6,1L	-2.2	-3.3	2.7	-1.9	0.3	1.7	1.6
17	3-S6,2L	-2.2	-3.3	2.7	-1.9	0.3	1.7	1.6
18	3-S3-S2	-2.0	-3.0	2.5	-1.8	0.3	1.6	1.6
19	3-S3-S2,1L	-2.0	-3.0	2.5	-1.8	0.3	1.6	1.6
20	3-S2-3	-2.0	-3.0	2.5	-1.8	0.3	1.6	1.6
21	RTAC 3-S3	-1.7	-3.0	2.1	-2.0	0.3	1.5	1.6
22	RTAC 3-S2-S2	-1.9	-3.0	2.3	-1.9	0.3	1.5	1.6
23	RTAC 3-S3-S2	-2.1	-3.1	2.5	-1.9	0.3	1.6	1.6
24	RTAC 3-S2=3	-2.0	-3.3	2.5	-2.0	0.3	1.7	1.6

Table 8.2 (cont.)/ Percentage Change in Costs per tne-km, Given a 10% Increase in Seven Variables, for High Axle Loads

	Configurations	1 Trip length	2 Hours	3 L/U time	4 Trip speed	5 Extra km	6 K cost	7 Over-heads
1	T3	-1.1	-2.6	1.3	-2.1	0.3	1.4	1.6
2	T4,1L	-1.4	-2.8	1.8	-2.0	0.3	1.5	1.6
3	T4 (twin steer)	-1.4	-3.0	1.7	-2.2	0.3	1.6	1.6
4	T3-2	-1.5	-2.8	1.8	-1.9	0.3	1.4	1.6
5	T3-3	-1.9	-2.9	2.3	-1.8	0.3	1.5	1.6
6	T3-4	-2.1	-3.0	2.6	-1.8	0.3	1.5	1.6
7	T4-4,1L	-2.2	-3.1	2.7	-1.8	0.3	1.6	1.6
8	3-S2	-1.5	-2.9	1.8	-2.1	0.3	1.5	1.6
9	3-S3	-1.7	-3.0	2.0	-2.0	0.3	1.5	1.6
10	3-S3,1L	-1.8	-3.0	2.2	-1.9	0.3	1.5	1.6
11	3-S4	-2.0	-3.0	2.5	-1.8	0.3	1.5	1.6
12	3-S4,1L	-2.0	-3.1	2.4	-1.9	0.3	1.5	1.6
13	3-S4,2L	-2.0	-3.0	2.5	-1.9	0.3	1.5	1.6
14	3-S5,1L	-2.1	-3.2	2.6	-2.0	0.3	1.6	1.6
15	3-S5,2L	-2.2	-3.3	2.6	-2.0	0.3	1.7	1.6
16	3-S6,1L	-2.1	-3.3	2.6	-2.0	0.3	1.7	1.6
17	3-S6,2L	-2.1	-3.3	2.6	-2.0	0.3	1.7	1.6
18	3-S3-S2	-2.0	-3.2	2.4	-2.0	0.3	1.6	1.6
19	3-S3-S2,1L	-2.0	-3.2	2.4	-2.0	0.3	1.6	1.6
20	3-S2-3	-2.0	-3.2	2.4	-2.0	0.3	1.6	1.6
21	RTAC 3-S3	-1.6	-3.1	2.0	-2.2	0.3	1.6	1.6
22	RTAC 3-S2-S2	-1.8	-3.0	2.2	-1.9	0.3	1.5	1.6
23	RTAC 3-S3-S2	-2.0	-3.2	2.5	-2.0	0.3	1.6	1.6
24	RTAC 3-S2=3	-1.9	-3.2	2.3	-2.1	0.3	1.7	1.6

Table 8.3/ Percentage Change in Costs per tne-km for Multivariate Changes for Maximum Axle Loads

	Configurations	Multi #1 +10%	Multi #2 -10%	Multi #3 high cost	Multi #4 low cost
1	T3	-1.2%	2.4%	25.9%	-21.6%
2	T4,1L	-1.3	2.5	28.6	-22.0
3	T4 (twin steer)	-1.5	2.8	29.3	-22.4
4	T3-2	-1.2	2.4	30.6	-22.2
5	T3-3	-1.1	2.4	31.5	-23.4
6	T3-4	-1.1	2.5	31.4	-24.0
7	T4-4,1L	-1.3	2.6	29.8	-24.3
8	3-S2	-1.3	2.6	31.4	-22.5
9	3-S3	-1.3	2.6	30.3	-23.6
10	3-S3,1L	-1.3	2.6	32.4	-23.3
11	3-S4	-1.3	2.6	32.2	-24.3
12	3-S4,1L	-1.3	2.6	32.1	-24.2
13	3-S4,2L	-1.3	2.6	31.3	-24.0
14	3-S5,1L	-1.4	2.7	32.7	-24.7
15	3-S5,2L	-1.4	2.8	32.6	-24.6
16	3-S6,1L	-1.6	3.0	30.9	-23.3
17	3-S6,2L	-1.6	3.0	30.8	-23.3
18	3-S3-S2	-1.3	2.6	31.7	-24.1
19	3-S3-S2,1L	-1.3	2.6	31.7	-24.1
20	3-S2-3	-1.3	2.6	31.7	-24.1
21	RTAC 3-S3	-1.5	2.9	27.5	-22.0
22	RTAC 3-S2-S2	-1.4	2.7	28.3	-22.6
23	RTAC 3-S3-S2	-1.4	2.7	29.1	-23.2
24	RTAC 3-S2=3	-1.7	3.1	27.4	-21.5

Table 8.3 (cont.)/ Percentage Change in Costs per tne-km for Multivariate Changes for High Axle Loads

	Configurations	Multi #1 +10%	Multi #2 -10%	Multi #3 high cost	Multi #4 low cost
1	T3	-1.3%	2.5%	23.3%	-20.1%
2	T4,1L	-1.4	2.6	26.1	-20.8
3	T4 (twin steer)	-1.6	2.9	26.7	-21.2
4	T3-2	-1.3	2.5	28.2	-21.0
5	T3-3	-1.2	2.5	29.2	-22.3
6	T3-4	-1.2	2.5	30.7	-23.3
7	T4-4,lL	-1.3	2.7	27.4	-23.7
8	3-S2	-1.5	2.8	27.5	-21.5
9	3-S3	-1.5	2.8	28.6	-21.9
10	3-S3,1L	-1.4	2.7	30.5	-22.4
11	3-S4	-1.3	2.7	30.4	-23.4
12	3-S4,1L	-1.4	2.8	29.8	-23.2
13	3-S4,2L	-1.4	2.7	29.5	-23.1
14	3-S5,1L	-1.6	3.0	29.3	-22.5
15	3-S5,2L	-1.6	3.1	28.7	-22.3
16	3-S6,1L	-1.7	3.1	29.0	-22.3
17	3-S6,2L	-1.6	3.1	29.3	-22.4
18	3-S3-S2	-1.5	2.9	28.2	-21.7
19	3-S3-S2,1L	-1.5	2.9	28.2	-21.7
20	3-S2-3	-1.5	2.9	28.2	-21.7
21	RTAC 3-S3	-1.7	3.1	25.7	-20.2
22	RTAC 3-S2-S2	-1.4	2.7	27.9	-22.3
23	RTAC 3-S3-S2	-1.6	3.0	27.3	-21.4
24	RTAC 3-S2=3	-1.7	3.1	27.0	-21.2

As shown on Table 8.3, the effect of all of these assumptions is very large. Costs under the high- and low-cost scenarios easily vary by +/- 20%, or even as much as 30% in some cases. This is on top of the assumptions about maximum/high axle loads and maximum/minimum tare weights. There are other variables that could also have been changed: trip length, payloads, and factor prices. However, changing any of these variables destroys the point of the analysis which is to compare trucking costs where hauling distances, loads, and factor prices are similar.

To put the effect of all of these assumptions in perspective, consider the Ontario (van) 3-S2. Given the axle load and/or tare weight possibilities, and given the effect of the above assumptions, here is what the model says about "trucking costs" at a given haul distance (160 km) assuming a backhaul and uniform factor prices (wage rate, fuel price, etc):

	3-S2 Base case	High costs	Low costs
Cents/tne-km	5.45 – 6.10	7.05 – 7.78	4.23 – 4.79

The highest cost is 84% greater than the lowest.

The above assumptions, and the variations in the assumptions (from the high to low cost cases) are all reasonable in light of all information collected. There is no reason to believe the assumptions of any one of the three cases is better or worse than the others. In light of this – the reasonableness of the assumptions – when this report uses the phrase "trucking costs are" it must be borne in mind, that – even with similar hauling distances, loads, and factor prices – costs can vary tremendously from one situation to another. It is emphasized that the costs discussed in this report are relative. They represent a reasonable range of trucking costs developed to understand some of the differences between the characteristics of one truck in comparison to another. They do not represent an absolute measurement of trucking costs.

This fact that trucking cost can vary tremendously from one situation makes it difficult to provide clear and concise answers to policy questions. When confronted with the question "What would be the effect on trucking costs if we did this to the allowable weight for liftable axles?" it is not possible to provide an unqualified answer. Truck "A" which has no liftable axles might be able to haul freight at 5 cents per tonne-kilometre – the same cost as a reasonable alternative truck with liftable axles does – but it might also haul freight at anywhere from 4 to 6.5 cents per tonne-kilometre. This does not mean that no answers are possible; but it does mean that the answers have to be understood in the context of certain qualifications. This research is concerned with certain "tendencies" in trucking costs, not absolute values.

9/ TRUCKING COSTS

Appendix L contains tables showing costs for 24 configurations, in three regions, with seven body styles, under four regulatory scenarios. There are several ways of summarizing this. Tables 9.1 to 9.6 show costs for the base case as a percentage of the 5-axle tractor-semitrailer, the most common large truck configuration. These indices are read down each column; the interest is in comparing costs as configurations change, not as different types of trailers are used (i.e., reading across each row). Although these percentages can be calculated from Appendix L, they are shown here both to provide a ready index of trucking costs and to emphasize that it is the relative values, not the absolute ones shown in Appendix L, which are important.

These relative costs on Tables 9.1 to 9.6 take no account of operational considerations. That is, they do not reflect any operational reasons (freight characteristics, terminal characteristics, etc.) as to why certain configurations might be preferred over others in certain situations.

Tables 9.7 to 9.13 show the costs of just those configurations with liftable axles. Again, costs have been indexed so that everything is shown as a percent of costs in the base case. Some of the minor (apparent) anomalies – for example, instances of where costs fall in higher-number scenarios – are caused by lower maintenance and tire costs as a result of the reduction in allowable GVWs. Further, on Table 9.13, no changes in costs between Scenario #1 and Scenario #5 are indicated: the only change that has occurred is that configurations with two liftable axles have been eliminated.

Finally, to emphasize the nature of the analysis, Figure 9.1 isolates the costs of one particular case – dump trucks in Ontario. The solid bars represent the range of costs per tonne-kilometre for each configuration within the maximum/high-axle loads used. So, for example, the 3-S2 can haul gravel at a cost of anywhere between 10.15 to 11.48 cents per tonne-kilometre (given the factor prices, productivity, and assumptions for such things as trip lengths, annual hours of operation, established in the preceding sections). The 3-S3,1L on the other hand can haul gravel at a cost between 8.53 and 9.26 cents per tonne-kilometre (given the same factor prices, productivity, and assumptions used for the 3-S2). It is highly unlikely, though, that any two trucks operate with identical factor prices, productivity, or other factors (annual hours, etc.). The effect of altering all of these factors was demonstrated, in part, in Section 8 where it was shown that the costs developed here could easily vary by a factor of +/- 25% (or more). To show this on Figure 9.1, a maximum and minimum point have been identified for each configuration. These are +/- 25% of the costs shown in the solid lines. Note that all six configurations are perfectly capable of hauling gravel at a cost of nine cents per tonne-kilometre, or, for that matter, at a range of costs anywhere between 7.61 to 9.79 cents per tonne-kilometre. In subsequent sections, the analysis will treat costs as if they are deterministic variables; in point of fact, trucking costs are better represented by probability functions. The treatment of costs here as discrete points is only for analytical convenience.

Table 9.1/ Trucking Cost Index: Ontario, Maximum Axle Loads ($/tne-km as % of 3-S2)

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
1	T3	128	131	131	132	121	130	126
2	T4,1L	96	95	99	96	89	95	92
3	T4 (twin steer)	100	98	103	100	93	99	96
4	T3-2	95	103	94	101	91	95	92
5	T3-3	84	89	83	89	79	82	80
6	T3-4	77	81	77	81	71	74	72
7	T4-4,1L	78	82	77	82	72	75	73
8	3-S2	100	100	100	100	100	100	100
9	3-S3	86	84	87	90	85	87	85
10	3-S3,1L	86	85	86	89	84	86	84
11	3-S4	82	80	82	84	79	84	79
12	3-S4,1L	82	80	82	84	79	84	79
13	3-S4,2L	81	80	81	83	78	83	78
14	3-S5,1L	81	79	81	83	78	83	79
15	3-S5,2L	80	79	81	83	78	83	78
16	3-S6,1L	80	78	80	84	79	84	79
17	3-S6,2L	80	78	80	84	79	84	79
18	3-S3-S2	89	94	88	95	91	93	90
19	3-S3-S2,1L	89	94	88	95	91	93	90
20	3-S2-3	90	95	89	95	93	94	91
21	RTAC 3-S3	97	98	97	105	99	101	98
22	RTAC 3-S2-S2	95	101	94	101	99	100	97
23	RTAC 3-S3-S2	88	94	87	94	90	92	89
24	RTAC 3-S2=3	92	98	91	99	97	98	95

Table 9.2/ Trucking Cost Index: Ontario, High Axle Loads ($/tne-km as % of 3-S2)

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
1	T3	132	133	136	143	132	134	135
2	T4,1L	93	89	96	95	88	90	91
3	T4 (twin steer)	99	95	103	103	95	97	98
4	T3-2	95	108	95	106	94	93	93
5	T3-3	79	84	79	85	79	79	76
6	T3-4	71	73	71	75	68	68	66
7	T4-4,1L	70	72	71	74	68	68	66
8	3-S2	100	100	100	100	100	100	100
9	3-S3	90	88	91	96	90	89	90
10	3-S3,1L	83	79	83	86	81	80	81
11	3-S4	76	72	78	79	75	76	74
12	3-S4,1L	78	74	79	82	77	79	77
13	3-S4,2L	76	71	77	78	74	75	73
14	3-S5,1L	73	69	74	77	73	74	72
15	3-S5,2L	73	68	73	76	72	73	71
16	3-S6,1L	76	72	77	80	75	77	75
17	3-S6,2L	76	72	77	80	76	77	75
18	3-S3-S2	81	87	82	89	88	87	83
19	3-S3-S2,1L	81	87	82	89	88	86	83
20	3-S2-3	82	88	83	90	86	84	84
21	RTAC 3-S3	92	91	92	100	93	92	93
22	RTAC 3-S2-S2	90	99	91	97	93	91	91
23	RTAC 3-S3-S2	80	85	80	87	85	84	81
24	RTAC 3-S2=3	86	94	87	94	90	88	88

Table 9.3/ Trucking Cost Index: Quebec, Maximum Axle Loads ($/tne-km as % of 3-S2)

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
1	T3	128	130	131	143	123	132	127
3	T4 (twin steer)	102	100	105	110	95	102	99
4	T3-2	94	102	93	107	91	95	92
5	T3-3	84	90	83	94	80	83	81
6	T3-4	85	91	85	97	82	85	83
8	3-S2	100	100	100	100	100	100	100
9	3-S3	85	85	86	89	84	86	84
10	3-S3,1L	85	84	85	88	84	86	84
12	3-S4,1L	92	92	93	98	91	98	92
18	3-S3-S2	93	101	92	104	99	101	98
19	3-S3-S2,1L	93	101	92	103	99	101	98
20	3-S2-3	98	105	96	107	105	106	102
21	RTAC 3-S3	100	101	100	108	101	103	101
22	RTAC 3-S2-S2	97	104	96	103	101	102	99
23	RTAC 3-S3-S2	90	96	89	97	92	94	91
24	RTAC 3-S2=3	94	101	92	101	99	100	97

Table 9.4/ Trucking Cost Index: Quebec, High Axle Loads ($/tne-km as % of 3-S2)

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
1	T3	130	130	134	153	130	133	133
3	T4 (twin steer)	98	93	101	109	94	96	97
4	T3-2	91	102	92	108	90	90	90
5	T3-3	78	83	79	90	79	79	76
6	T3-4	74	77	74	84	73	73	71
8	3-S2	100	100	100	100	100	100	100
9	3-S3	88	86	89	94	88	87	88
10	3-S3,1L	83	79	83	86	81	80	81
12	3-S4,1L	80	77	81	84	80	82	79
18	3-S3-S2	84	92	85	93	92	91	87
19	3-S3-S2,1L	84	92	85	93	92	90	87
20	3-S2-3	89	98	89	98	93	92	92
21	RTAC 3-S3	92	91	93	101	94	93	94
22	RTAC 3-S2-S2	90	99	91	97	92	91	91
23	RTAC 3-S3-S2	79	85	80	87	85	84	81
24	RTAC 3-S2=3	86	94	87	94	90	88	88

Table 9.5/ Trucking Cost Index: Atlantic, Maximum Axle Loads ($/tne-km as % of 3-S2)

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
1	T3	135	137	137	145	120	131	126
4	T3-2	98	107	96	108	91	95	91
5	T3-3	84	90	84	93	76	80	77
6	T3-4	81	86	80	89	73	77	74
8	3-S2	100	100	100	100	100	100	100
9	3-S3	85	84	86	90	84	86	84
10	3-S3,1L	85	83	85	89	83	85	83
18	3-S3-S2	91	98	90	100	95	97	94
20	3-S2-3	107	117	105	118	115	117	112
21	RTAC 3-S3	91	90	91	96	90	92	90
22	RTAC 3-S2-S2	91	96	90	95	93	94	91
23	RTAC 3-S3-S2	85	89	84	90	85	87	84
24	RTAC 3-S2=3	88	93	87	94	91	92	90

Table 9.6/ Trucking Cost Index: Atlantic, High Axle Loads ($/tne-km as % of 3-S2

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
1	T3	134	133	136	154	128	131	131
4	T3-2	92	105	92	108	89	89	88
5	T3-3	77	83	78	89	76	77	74
6	T3-4	73	76	73	82	70	71	68
8	3-S2	100	100	100	100	100	100	100
9	3-S3	86	83	87	92	85	84	86
10	3-S8,1L	81	78	82	86	81	80	81
18	3-S3-S2	84	93	85	95	93	91	87
20	3-S2-3	101	119	101	115	108	106	105
21	RTAC 3-S3	86	84	87	94	88	86	87
22	RTAC 3-S2-S2	85	92	86	92	87	85	85
23	RTAC 3-S3-S2	75	80	76	83	80	79	76
24	RTAC 3-S2=3	82	88	89	85	83	83	83

Table 9.7/ Maximum Axle Load Costs, Scenario #2 as % of Scenario #1
($/tne-km Scenario #2 as % of $/tne-km Scenario #1)

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
Ontario								
2	T4,1L	104	104	104	104	104	104	104
7	T4-4,1L	100	100	100	100	100	100	100
10	3-S3,1L	103	103	103	103	103	103	103
12	3-S4,1L	100	100	100	100	100	100	100
13	3-S4,2L	101	101	101	101	101	101	101
14	3-S5,1L	100	100	100	100	100	100	100
15	3-S5,2L	100	100	100	100	100	100	100
16	3-S6,1L	100	100	100	100	100	100	100
17	3-S6,2L	100	100	100	100	100	100	100
19	3-S3-S2,1L	100	100	100	100	100	100	100
Quebec								
10	3-S3,1L	104	104	104	104	104	104	104
12	3-S4,1L	100	100	100	100	100	100	100
19	3-S3-S2,1L	100	100	100	100	100	100	100
Atlantic								
10	3-S3,1L	102	102	102	102	102	102	102

Table 9.8/ High Axle Load Costs, Scenario #2 as % of Scenario #1
($/tne-km Scenario #2 as % of $/tne-km Scenario #1)

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
Ontario								
2	T4,1L	109	108	107	109	109	109	109
7	T4-4,1L	100	100	100	100	100	100	100
10	3-S3,1L	103	103	102	104	104	104	104
12	3-S4,1L	104	104	104	105	105	105	104
13	3-S4,2L	102	102	102	103	103	103	103
14	3-S5,1L	100	100	100	100	100	100	100
15	3-S5,2L	100	100	100	100	100	100	100
16	3-S6,1L	100	100	100	100	100	100	100
17	3-S6,2L	100	100	100	100	100	100	100
19	3-S3-S2,1L	100	100	100	100	100	100	100
Quebec								
10	3-S3,1L	103	103	103	104	104	104	104
12	3-S4,1L	99	100	99	106	101	101	101
19	3-S3-S2,1L	100	100	100	100	100	100	100
Atlantic								
10	3-S3,1L	102	103	102	103	103	103	103

Table 9.9/ Maximum Axle Load Costs, Scenario #3 as % of Scenario #1
($/tne-km Scenario #3 as % of $/tne-km Scenario #1)

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
Ontario								
2	T4,1L	110	113	111	112	112	112	112
7	T4-4,1L	100	100	100	100	100	100	100
10	3-S3,1L	107	107	107	108	108	108	108
12	3-S4,1L	102	102	102	102	102	102	102
13	3-S4,2L	105	106	106	108	108	108	108
14	3-S5,1L	100	100	100	100	100	100	100
15	3-S5,2L	100	100	100	100	100	100	100
16	3-S6,1L	100	100	100	100	100	100	100
17	3-S6,2L	100	100	100	100	100	100	100
19	3-S3-S2,1L	100	100	100	100	100	100	100
Quebec								
10	3-S3,1L	108	109	108	109	109	109	109
12	3-S4,1L	100	100	100	100	100	100	100
19	3-S3-S2,1L	100	100	100	100	100	100	100
Atlantic								
10	3-S3,1L	107	107	107	108	108	108	108

Table 9.10/ High Axle Load Costs, Scenario #3 as % of Scenario #1
($/tne-km Scenario #3 as % of $/tne-km Scenario #1)

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
Ontario								
2	T4,1L	117	118	117	119	119	119	119
7	T4-4,1L	100	100	100	100	100	100	100
10	3-S3,1L	108	109	108	110	110	110	110
12	3-S4,1L	104	105	104	107	107	107	107
13	3-S4,2L	105	108	105	110	110	111	110
14	3-S5,1L	100	100	100	100	100	100	100
15	3-S5,2L	104	104	104	105	105	105	104
16	3-S6,1L	100	100	100	100	100	100	100
17	3-S6,2L	100	100	100	100	100	100	100
19	3-S3-S2,1L	100	100	100	100	100	100	100
Quebec								
10	3-S3,1L	108	110	108	110	110	110	110
12	3-S4,1L	103	105	103	107	106	107	106
19	3-S3-S2,1L	100	100	100	100	100	100	100
Atlantic								
10	3-S3,1L	103	105	103	107	106	106	106

Table 9.11/ Maximum Axle Load Costs, Scenario #4 as % of Scenario #1
($/tne-km Scenario #4 as % of $/tne-km Scenario #1)

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
Ontario								
2	T4,1L	135	141	135	143	142	143	141
7	T4-4,1L	101	101	101	101	101	101	101
10	3-S3,1L	115	118	115	122	121	121	121
12	3-S4,1L	111	112	111	114	114	115	114
13	3-S4,2L	131	137	131	143	141	144	142
14	3-S5,1L	99	99	99	101	101	101	101
15	3-S5,2L	111	114	112	117	116	117	117
16	3-S6,1L	100	100	100	100	100	100	100
17	3-S6,2L	103	103	103	103	103	104	103
19	3-S3-S2,1L	98	99	98	101	101	101	100
Quebec								
10	3-S3,1L	120	123	121	126	125	125	125
12	3-S4,1L	100	100	100	100	100	100	100
19	3-S3-S2,1L	100	100	100	100	100	100	100
Atlantic								
10	3-S3,1L	119	124	119	126	125	125	125

Table 9.12/ High Axle Load Costs, Scenario #4 as % of Scenario #1
($/tne-km Scenario #4 as % of $/tne-km Scenario #1)

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
Ontario								
2	T4,1L	149	160	148	162	160	160	158
7	T4-4,1L	99	100	99	101	101	101	101
10	3-S3,1L	122	131	122	130	129	129	129
12	3-S4,1L	119	125	120	126	126	127	125
13	3-S4,2L	144	160	145	158	158	162	156
14	3-S5,1L	102	103	103	103	103	103	103
15	3-S5,2L	135	143	136	143	142	144	142
16	3-S6,1L	100	100	100	100	100	100	100
17	3-S6,2L	102	103	102	103	103	103	103
19	3-S3-S2,1L	103	103	103	103	103	103	103
Quebec								
10	3-S3,1L	123	131	122	131	130	130	129
12	3-S4,1L	120	126	120	127	126	128	126
19	3-S3-S2,1L	100	100	100	100	100	100	100
Atlantic								
10	3-S3,1L	124	133	124	132	130	130	130

Table 9.13/ Maximum or High Axle Load Costs, Scenario #5 as % of Scenatio #1 ($/tne-km Scenario #5 as % of $/tne-km Scenario #1)

	Configurations	Van	Reefer	Flat	Tank	Dump	Hopper	Log
Ontario								
2	T4,1L	100	100	100	100	100	100	100
7	T4-4,1L	100	100	100	100	100	100	100
10	3-S3,1L	100	100	100	100	100	100	100
12	63-S4,1L	100	100	100	100	100	100	100
14	3-S5,1L	100	100	100	100	100	100	100
16	3-S6,1L	100	100	100	100	100	100	100
19	3-S3-S2,1L	100	100	100	100	100	100	100
Quebec								
10	3-S3,1L	100	100	100	100	100	100	100
12	3-S4,1L	100	100	100	100	100	100	100
19	3-S3-S2,1L	100	100	100	100	100	100	100
Atlantic								
10	3-S3,1L	100	100	100	100	100	100	100

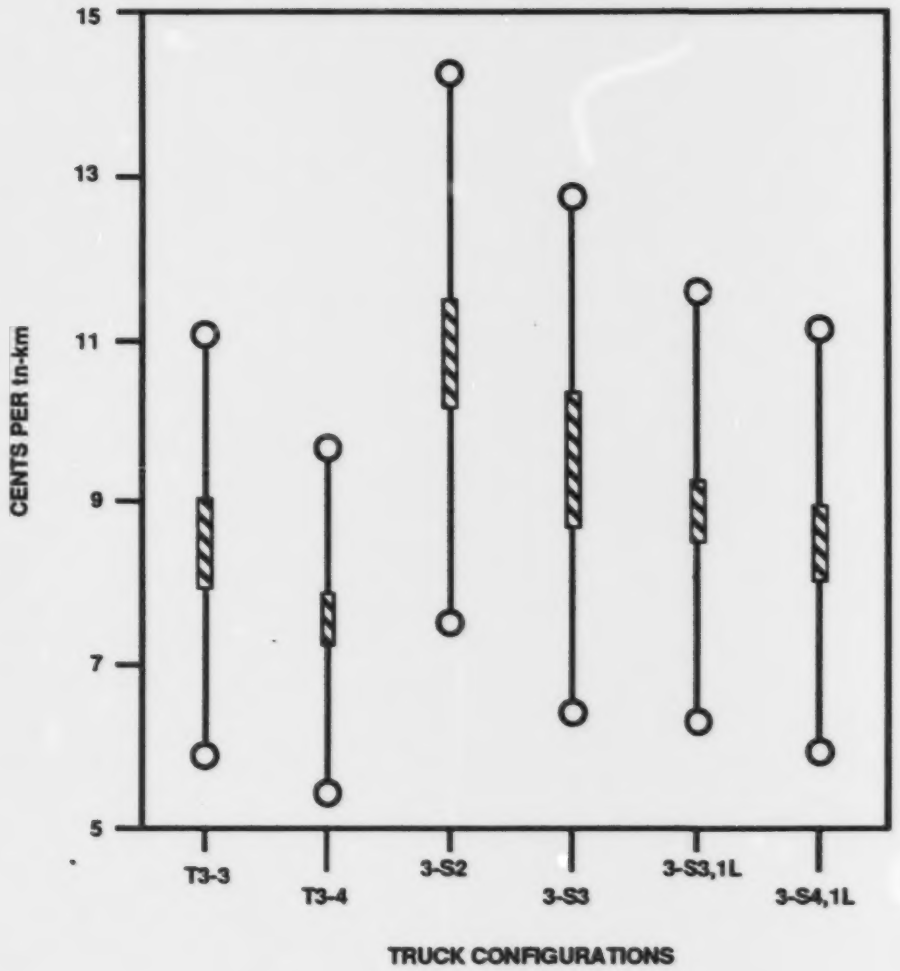

Figure 9.1/ Range in Trucking Costs

10/ TRUCKING COSTS AND REGULATORY SCENARIOS

This section contains an analysis of the impact of Scenarios #2 through #5. It consists of an evaluation of how freight shifts from one configuration to another as regulations governing liftable axles change. It is, in part, a subjective analysis. The subjectiveness, however, is backed up by the costs developed in earlier sections. There are also two assumptions employed. The first is that there is a tendency for freight to be hauled by similar configurations under each scenario. For example, if the effect of a scenario is to increase the costs of hauling freight on straight trucks with liftable axles, there will be a tendency to shift this freight to alternative straight truck configurations, rather than tractor-semitrailers. A second assumption is that the costs generated with high axle loads, rather than maximums, are the most relevant: these are typical of trucks hauling heavy commodities in central and Atlantic Canada.

The predictions made in this analysis are not precise. The intent is to make one reasonable prediction so that the consequences of the regulatory scenarios can be evaluated. In all cases, while actual events will be more complex than those predicted, the range of costs is broad enough to capture the maximum amount that freight costs need to change, given the alternatives available.

RTAC trucks, except for the RTAC B-train in Quebec and Atlantic Canada, do not play much of a role in this analysis as local configurations allow greater payloads. Nevertheless, in practice, some shifts would be to RTAC trucks as carriers sought out equipment that could be used in all provinces. The substitution of RTAC configurations would not affect the analysis significantly as their costs fall within the same range as those used here.

10.1/ The T4,1L

Straight trucks with liftable axles are only important in Ontario. A few may exist in Quebec and Atlantic Canada under permit; however, if they do, their numbers are small. With a slightly higher payload and a slightly lower purchase price, they can haul freight at a lower cost than the T4 (tandem-steer). It is predicted (see Tables 9.1 and 9.2) that under Scenarios #2, #3, and #4, carriers would replace their T4,1L's with T4's and freight costs would increase by 4 to 8%.

10.2/ The T4-4,1L

Truck-plus-trailers with liftable axles are also only important in Ontario. They have a slight payload advantage over the T3-4 (only half a tonne, despite the fact they have one more axle). This small advantage, coupled with a higher purchase price, means there is little difference between freight costs on the T4-4,1L and the T3-4 (see Tables 9.1 and 9.2). It is predicted, then, that under Scenarios #2, #3, and #4, freight would shift from the T4-4,1L to the T3-4 (and other configurations) with no change in freight costs.

10.3/ The 3-S3,1L

The 3-S3,1L is the most common liftable-axle configuration in all three regions, accounting for almost three-quarters of total tonnages carried in eastern Canada by liftable-axle trucks. Its popularity owes much to the fact that it has a large payload advantage over the even more common 5-axle tractor-semitrailer – a payload advantage of 21 to 40% depending on the region and body style – and the fact that it can haul dense freight at a considerably lower cost than the 3-S2. Even in comparison to the 3-S3, the 3-S3,1L is far more popular; one of the reasons is the extreme spreads that have to be used on a 3-S3 to give it the same payload as the 3-S3,1L and the consequent increase in operating costs such spreads would create.

If liftable-axle loads are reduced, some bulk freight such as aggregates, building supplies, and logs would shift from the 3-S3,1L to a truck-plus-trailer. In other words, where operational considerations do not require the use of a tractor-semitrailer, the T3-3 or the T3-4 become serious contenders for the freight now hauled by the 3-S3,1L. This might occur, for example, where the freight-carrying unit (trailer or straight truck) does not have to be left at a shipper's door for loading or unloading. Table 10.1 shows how one truck-plus-trailer compares with the 3-S3,1L. These are shown only for high axle loads. (Also note that there is probably no such thing as a straight truck with a hopper).

Table 10.1/ T3-3 Costs Versus the 3-S3,1L (comparison of $/tn-km)

Region	Body Style	T3-3 Costs Compared to 3-S3,1L
Ontario	Van, flatdeck, log	-5% to -6%
	Refrigerated	+6%
	Tank, hopper	-1%
	Dump	-3%
Quebec	Van, flatdeck, log	-5% to -6%
	Refrigerated, tank	+5%
	Dump, hopper	-1% to -2%
Atlantic	Van, flatdeck, dump	-5%
	Refrigerated, tank	+3% to +6%
	Hopper	-3%
	Log	-8%

The T3-4 can haul freight at even lower costs than the T3-3. This cost advantage of the T3-3 or the T3-4, given the right operational circumstances, increases as the allowed load on the liftable axle of the 3-S3-,1L is lowered.

For freight for which operational considerations do favour the use of tractors and semitrailers, the nearest competitor to the 3-S3,1L is the 3-S3 with its wide-spread fixed axle. (The 3-S3,1L has such a cost advantage over the 3-S2 that it is assumed that a 5-axle configuration is not an option.) The 3-S3 is compared with the 3-S3,1L in Table 10.2. The first column compares the 3-S3,1L with a 3-S3 having typical wide-spread tridems (in the range of 3.66 m). The second column compares it with the "very-wide-spread" 3-S3 (for example, three "independent" single axles). These "very-wide-spread" 3-axle groups are relatively rare – there are operational problems if they are used in situations where a lot of turning is required.

Table 10.2/ 3S-3 Costs Versus the 3-S3,1L (comparison of $/tn-km)

Region	Scenario	3-S3 Costs Versus 3-S3,1L	
		3-S3 with wide-spread axles	3-S3 with very-wide-spread axles
Ontario	Current	+8% to +10%	little difference
	Scenario #2	+6% to +7%	-2% to -3%
	Scenario #3	+1% to +2%	-6% to -8%
Quebec	Current	+7% to +9%	little difference
	Scenario #2	+4% to +5%	-3% to -4%
	Scenario #3	-1%	-8% to -9%
Atlantic	Current	+5% to +6%	little difference
	Scenario #2	+3%	-1%
	Scenario #3	+1% to +2%	-6% to -7%

For freight that did not shift to the 3-S3, another possibility is the 3-S4,1L. In fact, anecdotal evidence suggests carriers are replacing 3-S3,1L equipment now with 3-S4,1L equipment even without the impetus of a change in regulations on liftable axles. As the load on liftable axles is reduced under Scenarios #2 and #3, carriers in Ontario and Quebec could maintain current payloads by adding one extra axle (that is, purchasing 4-axle semitrailers to replace 3-axle ones). Hauling costs for the 3-S4,1L under Scenario #2 or Scenario #3 are close to current hauling costs for the 3-S3,1L as shown in Table 10.3.

Table 10.3/ The 3S-4,1L as a Replacement for the 3-S3,1L
(comparison of $/tn-km)

	Van	Reefer	Flat	Tank	Dump	Hopper	Log
	S-34,1L Costs Scenario #2 Versus 3-S3,1L Costs Scenario #1						
Ontario	-1.5%	-1.4%	-1.0%	-0.4%	+0.3%	+3.8%	-0.9%
Quebec	-3.7%	-2.9%	-3.2%	+4.0%	+0.1%	+3.5%	-1.4%
	S-34,1L Costs Scenario #3 Versus 3-S3,1L Costs Scenario #1						
Ontario	-1.7%	-0.6%	-1.2%	+2.1%	+2.5%	+6.3%	+1.1%
Quebec	+0.6%	+2.2%	+1.1%	+4.7%	+5.2%	+9.1%	+3.6%

The predictions as to the consequences of various scenarios have to be broken into two parts. First, for "rough" bulk freight (anything suitable to truck-plus-trailers), freight would likely shift to the T3-3 or other straight-truck combinations with a *decrease* in costs between 3 and 6% in Ontario, 1 to 6% in Quebec, and 5 to 8% in Atlantic Canada. Second, for "other" freight (anything where operational circumstances favoured the use of tractor-semitrailers), freight would likely shift either (a) to the 3-S3 with an increase in costs of between 0 and 10% in Ontario, 0 to 9% in Quebec, and 0 to 6% in Atlantic Canada, or (b) in Ontario and Quebec only, under Scenario #2 and #3, to the 3-S4,1L with most cost changes in the range of +/- 2% in Ontario and +/- 4% in Quebec. Since the 3-S4,1L under Scenario #2 and #3 hauls freight at costs quite close to the costs of the current 3-S3,1L, the range of estimated cost changes given in the first part ("a") of this prediction are probably close enough to include the range of predictions in the second part ("b").

10.4/ The 3-S4,1L and 3-S4,2L

The 3-S4,1L and, to a smaller extent, the 3-S4,2L are common in Ontario for such uses as dump trucks or flatdecks hauling steel and other heavy commodities. The new policy in Quebec allows the 3-S4,1L at 55 500 kilograms; the remaining 3-S4,2L configurations in Quebec will not have their permits renewed (and are not considered here). The 7-axle tractor-semitrailer (all three varieties in Ontario) can haul many types of freight at a lower cost than any other tractor-trailer combination (see Table 9.1 and Table 9.2 and, in particular, the costs shown for the 3-S4, the 3-S4,1L, and the 3-S4,2L).

As loads on liftable axles are reduced, the effect on the 3-S4,1L would be similar to the 3-S3,1L. That is, there would be a tendency for the "rough" bulk freight to shift to the T3-4 and for other freight to shift to double-trailer combinations. In Quebec, the tendency will be for freight to shift to the 3-S3 with very wide-spread tri-axles, or to doubles. A comparison of 3-S4,1L costs with other configurations is shown on Table 10.4; these are shown only for high axle loads.

There are two special points to note about these comparisons. First, the 3-S4 in Ontario actually can haul freight at a lower cost than the 3-S4,1L. The reason for this is the slightly higher payloads possible when a tractor-semitrailer has four axles spaced very far apart on a semitrailer in Ontario. Fixed costs for the two units are quite similar and running costs are slightly higher for the 3-S4 (the wide-spread axle and the axle-load assumptions). However, the qualification to this observation is that carriers find such wide-spread fixed axle groups troublesome (operational problems and maintenance costs, etc.). The second observation concerns the refrigerated body style. Specifically, the figures on Table 10.4 reflect the large increase in costs associated with moving from single-trailer to double-trailer configurations when expensive refrigeration units and high ratios of tare weight to payload are involved.

Table 10.4/ 3S-4,1L Costs Versus the T3-4, 3-S4, or 3-S3-S3
(comparison of $/tn-km)

Region	Body Style	3-S4,1L Costs Versus T3-4
Ontario	all, except refrigerated	+9% to +13%
	refrigerated	+2%
Quebec	van, flatdeck, dump, hopper, log	+8% to +10%
	refrigerated, tank	0
		3-S4,1L costs versus 3-S4*
Ontario	all	+2% to +4%
		3-S4,1L versus 3-S3-S2
Ontario	all, except refrigerated	-3% to -12%
	refrigerated	-15%
Quebec	all, except refrigerated	-4% to -13%
	refrigerated	-17%

* There is some question, however, as to whether or not such a configuration actually exists.

As with the 3-S3,1L, the predictions as to the consequences of freight hauled by the 3-S4,1L and the 3-S4,2L under various scenarios have to be broken into two parts. For "rough" bulk freight (anything suitable to truck-plus-trailers), freight would likely shift to the T3-4 (or other truck-trailer combinations) with a decrease in costs of between 9 and 13% in Ontario, and 8 to 10% in Quebec. For other freight, freight would likely shift to the 3-S4 or the 8-axle Ontario or RTAC B-train (or other combinations) with a change in costs of anywhere from -3% to +12% in Ontario. In Quebec,

freight would shift to the RTAC B-train with a cost increase of between 4 and 13%. The shifts in all cases ("rough" or "other," Ontario or Quebec) would be gradual as the change in costs for the 3-S4,1L or the 3-S4,2L is quite small as liftable axle loads are reduced from 10 000 to 8 000 or from 10 000 to 6 000 kilograms (see Tables 9.7 to 9.10).

10.5/ Other Liftable-Axle Configurations

With the exception of a few 8-axle B-trains in Quebec, all remaining configurations with liftable axles are in Ontario. As shown on Tables 9.7 to 9.10, these are affected slightly by a reduction in allowable liftable axle loads to 8000 or 6000 kilograms. The reason is that most of them have "excess axle-load capacity." It is true, however, that much of the flexibility of these configurations is impaired as the allowable load on liftable axles is reduced. That is, the ability to place loads at various places on the truck is degraded.

If freight does shift from these configurations, the most likely replacement is the B-train. A comparison of multi-axle semitrailers and B-trains is shown on Table 10.5, with costs developed only with high axle loads.

Table 10.5/ Multi-Axle Semitrailers Versus B-Trains
(comparison of $/tn-km)

Region	Body Style	Multi-axle Semi's Costs Versus 3-S3-S2
Ontario	Van	-7% to -11%
	Refrigerated	-18% to -21%
	Flatdeck	-6% to -10%
	Tank	-9% to -14%
	Dump	-13% to -18%
	Hopper	-10% to -15%
	Log	-10% to -14%

It is predicted that, under Scenarios #2 and #3, there would be no significant impact on freight carried by these configurations. Under Scenario #4, some freight would shift to other configurations, although there are still some of these multi-axle semitrailer combinations which could continue to carry freight at a cost of only 3% or so more than under the base case. That is, there is enough "excess axle-load capacity" that they are barely affected by the ban on liftable axles.

10.6/ Summary

Tables 10.6 to 10.8 summarize the predicted impact of the regulatory scenarios, based on the comparative hauling costs of each configuration.

Table 10.6/ Summary of Analysis, Ontario

	Scenario	Shift To	Freight Affected	Cost Change
T4,1L	#2	T4	50%	+4% to +8%
	#3, #4	T4	100%	+4% to +8%
	#5	no change		0
T4-4,1L	#2,#3,#4	T3-4	100%	0
	#5	no change		0
3-S3,1L				
"rough" freight	#2	T3-3	33%	-3% to -6%
	#3	T3-3	67%	-3% to -6%
	#4	T3-3	100%	-3% to -6%
	#5	no change		0
other freight	#2	3-S3 or 3-S4,1L	33%	0 to +10%
	#3	3-S3 or 3-S4,1L	67%	0 to +10%
	#4	3-S3	100%	0 to +10%
	#5	no change		0
3-S4,1L & 3-S4,2L				
"rough" freight	#2	T3-4	20%	-9% to -13%
	#3	T3-4	40%	-9% to -13%
	#4	T3-4	100%	-9% to -13%
	#5	no change		0
other freight	#2	3-S4	20%	-3% to +12%
	#3	3-S4	40%	-3% to +12%
	#4	3-S4	100%	-3% to +12%
	#5	no change		0
other configurations				
	#2,#3	no change		0
	#4	no change	100%	+2% to +3%
	#5 2L only	3-S3-S2	100%	+6% to +21%

Table 10.7/ Summary of Analysis, Quebec

	Scenario	Shift To	Freight Affected	Cost Change
3-S3,1L				
"rough" freight	#2	T3-3	33%	-1% to -6%
	#3	T3-3	67%	-1% to -6%
	#4	T3-3	100%	-1% to -6%
	#5	no change		0
other freight	#2	3-S3 or 3-S4,1L	33%	0 to +9%
	#3	3-S3 or 3-S4,1L	67%	0 to +9%
	#4	3-S3	100%	0 to +9%
	#5	no change		0
3-S4,1L				
"rough" freight	#2	T3-4	20%	-8% to -10%
	#3	T3-4	40%	-8% to -10%
	#4	T3-4	100%	-8% to -10%
	#5	no change		0
other freight	#2	3-S4	20%	+4% to +13%
	#3	3-S4	40%	+4% to +13%
	#4	3-S4	100%	+4% to +13%
	#5	no change		0

Table 10.8/ Summary of Analysis, Atlantic Canada

	Scenario	Shift To	Freight Affected	Cost Change
3-S3,1L				
"rough" freight	#2	T3-3	33%	-5% to -8%
	#3	T3-3	67%	-5% to -8%
	#4	T3-3	100%	-5% to -8%
	#5	no change		0
other freight	#2	3-S3	33%	0 to +6%
	#3	3-S3	67%	0 to +6%
	#4	3-S3	100%	0 to +6%
	#5	no change		0

11/ FREIGHT FLOWS AND TRUCKS

This section develops estimates of the importance of trucks with liftable axles in terms of truck traffic and freight movements. The difficulty in doing this is to find data on the relationship between freight flows and truck configurations. It is done here using Statistics Canada's commodity data, road-side surveys, and, in Section 12, an integration of these two sources.

Table 11.1 shows the freight flows from Statistics Canada [2]. Total (surveyed) truck traffic was 181.5 million tonnes in 1987. There are omissions from this estimate: international movements, movements by private carriers with less than 15 vehicles, and movements by the very small for-hire carriers. Moreover, data on commodity flows are not directly convertible to truck trips.

Table 11.1/ Total Freight Flows, 1987 – Statistics Canada, tonnes

		Destination	
Origin	Atlantic	Quebec	Ontario
Atlantic	18 943 511	819 837	685 162
Quebec	896 543	48 458 001	6 424 580
Ontario	760 765	6 252 400	99 286 249

Road-side surveys are conducted on an irregular basis and their usefulness is mainly for forecasting the evolution of traffic flows. They indicate the number of trucks passing a given point, but care has to be taken in using them as without information on trip characteristics, particularly the length of haul, the commodity carried and its weight and the truck configuration, it is difficult to translate these numbers into daily or annual measures of truck activity.

In 1989, Quebec conducted a survey of trucks on its highways [3]. This provides a picture of intercity trucking in terms of such elements as the trip, commodity, carrier characteristics, configurations, body style, payload, length of haul, etc. The number of trucks surveyed was 2681 and an overview is presented in Table 11.2. Tractor-semi-trailers are the largest component of the Quebec fleet (50%). The highest number of liftable axles is also found on the tractor-semitrailers – 542 or 95% of the total (569) – with 40.5% of all tractor-semitrailers having at least one liftable axle. Average payloads, as expected, are heavier for trucks with liftable axles than for trucks without liftable axles. For example, the average payload for tractor-semitrailers with liftable axles is 33.7% higher than the average for tractor-semitrailers without liftable axles.

Table 11.2/ Quebec Vehicle Configurations – Quebec 1989 Road-Side Survey

Vehicle configuration	Number	Liftable axles Without	With	Average Payload (kg) Without	With
Tractor-Semitrailer	1 340	798	542	22 527	30 125
Double (A-B- or C-train)	74	62	22	31 817	34 072
Straight Trucks	1 176	1 176	0	8 570	--
Truck-trailer	41	36	5	29 020	??
Others	50	50	0	--	--

Table 11.3/ Quebec: The Use of Liftable Axles – Quebec 1989 Road-Side Survey

	Total Trucks	Total Tonnes
A) Trucks without liftable axles	78.8%	67.6%
B) Trucks with liftable axles	21.2	32.4
Configurations		
- tractor-semitrailer	20.2	30.9
- double trailer	0.8	1.1
- straight truck	0.0	0.0
- truck + trailer	0.2	0.4
Body Style (tractor-semitrailer only)		
- van & refrigerated	7.0	8.2
- flatbed & stake	8.0	13.2
- tanker	3.3	5.8
- dump	1.7	3.4
- other	0.2	0.3

Table 11.4/ Quebec: Payloads for Tractor-Semitrailers with Liftable Axles
Quebec 1989 Road-Side Survey, kilograms

Body Styles	Number of axles			
	6		7	
	Min.	Max.	Min.	Max.
Van	25 479	27 792	32 572	32 709
Refrigerated	14 629	17 848	12 966	16 322
Flatdeck	26 045	28 132	34 575	36 782
Tanker	27 011	28 870	36 125	38 075
Dump	33 003	34 863	38 817	40 950

Table 11.3 provides more detail on the use of liftable axles in Quebec. As shown, 21.2% the trucks have liftable axles, but these account for almost a third of total tonnes hauled. Tractor-semitrailers with liftable axles account for 20.2% of the traffic and nearly 31% of the tonnes. Three body styles account for most liftable axles: vans (including refrigerated vans), flatdecks (including stake and rack), and tankers. Finally, Table 11.4 presents the average payload by body style for 6- and 7-axle units with liftable axles.

The Ontario road-side survey of 1988 provides a picture of trucking activity on Ontario highways. Only partial results were available for this research (results are still being tabulated). The 7943 trucks sampled and on which records were available are shown in Table 11.5. Tractor-semitrailers use the most – 91.6% of the total – liftable axles. In other terms, 18.1% of tractor-semitrailers have liftable axles and the average payload carried by these trucks is 63.1% higher than the same truck without liftable axles.

Table 11.6 shows the relative importance of liftable axles in Ontario for various configurations, body styles, and commodities. Just under 17% of the trucks have liftable axles and these account for one-quarter of the tonnes hauled.

Tractor-semitrailers, particularly 6-axle ones, make the most use of liftable axles. Vans (including refrigerated) and flatdecks (including stake & rack) account for 80% of all liftable axles. Finally, the top seven commodities carried by trucks with liftable axles are shown at the bottom of the table; most are in the "fabricated materials, inedible" category of the Standard Commodity Classification.

Table 11.5/ Ontario Truck Configurations – Ontario 1988 Road-Side Survey

Vehicle Configuration	Number	Liftable Axles		Average Payload (kg)	
		Without	With	Without	With
Tractor-Semitrailer	6 738	5 520	1 218	13 275	21 656
Train Double (A-B-C)	483	413	70	24 115	30 719
Straight Trucks	654	634	20	4 176	10 452
Truck-trailer	65	43	22	21 007	29 036

Table 11.7 shows average payloads by body style in Ontario in more detail – by the number of axles of each tractor-semitrailer configuration. There may be errors in the source data as some of the high payloads are difficult to explain. A high percentage of liftable axles are used by combinations having 6 and 7 axles; among these units, 80.5% are van, reefer, or flatdecks. As shown on Table 11.7, configurations having more axles carry higher payloads than those having fewer axles. Interestingly, while the overview of the data in Table 11.5 suggests that trucks with liftable axles have higher payloads than trucks without liftable axles, the data in Table 11.7 show that some care has to be taken with this generalization. When the number of axles is held constant, the figures in Table 11.7 show that some of the fixed-axle configurations carry just as much weight as, or more weight than, the liftable-axle configurations. For example, the 3-S3 for the van, refrigerated van, flatdeck, tanker, dump, and hopper carries more payload than the comparable 3-S3,1L configurations. Similarly, the 3-S4 in all body styles carries more payload than the 3-S4,1L or the 3-S4,2L, although in this case, it is known that the source data may have problems distinguishing between the various 7-axle tractor-semitrailers. The explanation for this (apparently) odd phenomenon is that there are more partially loaded, liftable trucks in the data base than there are fixed-axle trucks. The figures in Table 11.7 include loaded and partially loaded – but not empty – trucks.

Table 11.6/ Ontario: Use of Liftable Axles – Ontario 1988 Road-Side Survey

	Total Trucks	Total Tonnes
A) Trucks without Liftable Axles	83.3%	74.8%
B) Trucks with Liftable Axles	16.7	25.3
Number of Axles		
- 5 or fewer axles	2.2	2.1
- 6 axles	9.5	13.4
- 7 axles	3.3	6.3
- 8 or more axles	1.8	3.4
Configuration		
- tractor-semitrailer	15.3	22.7
- double trailer	0.9	1.9
- straight truck	0.3	0.2
- truck + trailer	0.3	0.6
Body Style		
- van	7.9	9.9
- flatbed & stake	5.6	9.4
- dump	1.5	3.0
- tanker	0.9	1.6
- other	0.9	1.4
Commodities Carried		
- iron/steel/alloys	3.3	6.1
- chemicals & related	1.5	2.1
- paper & paperboard	1.1	1.8
- crude non-metallic minerals	1.0	2.2
- wood fabricated materials	1.0	1.9
- non-metallic mineral basic prod.	1.0	1.6
- mixed goods	1.0	0.8
- other	6.8	8.8

Information for the Atlantic provinces is drawn from the 1984 Atlantic Provinces Origin-Destination Survey (the data was supplied by the University of New Brunswick Transportation Group). This allows a distribution of trucks and tractor-semitrailers by axle numbers to be developed, as shown in Table 11.9. There were 87 239 trucks captured in the survey, of which the tractor-semitrailer accounted for 51 360 or 58.9%. Moreover, the 6-axle tractor-semitrailer is the most important unit, representing 40.6% of all trucks on the road in Atlantic Canada. While precise numbers are not available, most of these have liftable axles (i.e., are 3-S3,1L configurations).

While data on tonnages by each configuration were not directly available, estimates have been developed on the basis of the ESALs measured for each truck (i.e., the "equivalent-single-axle-loads" for each configuration can be converted to an estimate of GVW which can then be converted to an estimate of payloads by subtracting the estimated tare weights).

Table 11.7/ Ontario Tractor-Semitrailers: Payloads x Body Style
Ontario 1988 Road-Side Survey, kilograms

	Number of axles				
Body Styles	5	6	7	8	9
Van					
with	12 311	18 658	27 270	22 030	---
without	11 335	19 311	27 811	25 152	---
Refrigerated					
with	13 699	17 555	17 807	54 924	11 175
without	13 415	20 131	20 202	35 737	---
Flatdeck					
with	11 946	20 309	28 384	28 199	27 223
without	15 440	22 168	29 152	30 887	32 599
Tanker					
with	16 964	23 302	26 467	52 327	43 932
without	18 036	26 201	32 768	34 069	36 343
Dump					
with	30 541	28,715	34 402	37 805	25 952
without	19 660	28,836	35 510	20 251	---
Hopper					
with	32 858	31 459	23 822	25 550	---
without	23 066	32 241	39 437	20 003	---
Others					
with	-----	-----	-----	-----	-----
without	-----	-----	-----	-----	-----

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with/without = with/without liftable axles

Table 11.8/ Atlantic Canada: Configurations – Atlantic Provinces 1984 O/D Survey

	Total Trucks		Estimated Tonnes
	Number	Percent	Percent
Straight Trucks		41.1	
2 axles	16 271	18.7	
3 axles	19 608	22.4	4.0
Tractor-Semitrailers		58.9	
3-S2	14 041	16.1	48.1
3-S3 & 3-S3,1L	35 453	40.6	27.7
3-S4 & 3-S4, 1L		642	0.7
3-S2-S2	1 224	1.4	5.9

12/ FREIGHT FLOWS, TRUCK CONFIGURATIONS, AND TRUCKING COSTS

The third step in the analysis consists of linking freight flows to vehicle configurations, making it possible to calculate the costs each configuration incurs when hauling commodities and, consequently, the change in trucking costs that would occur if policies on liftable axles were modified. Before describing this methodology, it is helpful to review how a trucking firm determines the composition of its fleet.

A carrier, when choosing a truck to maximize profits, is constrained by various considerations: capital cost, operating cost, volume of cargo space, payload-weight capacity, ability to operate in different jurisdictions, use of owner-operators, durability, manoeuvrability, versatility, and registration fees. The fleet mix is also determined by the regulations covering gross vehicle weight, axle loads, axle spreads, inter-axle spacings and so on. Finally a firm's choice is constrained by operational characteristics such as load size, haul distance, composition of commodities carried (weigh-out or cube-out), operations network (urban and intercity), backhaul trips, and so on. In other words, the fleet composition of every carrier reflects, in one way or another, all of these considerations. To model truck choice as function of variables representing these characteristics is not possible, as there exists no Canadian data to validate such a model. The data from road-side surveys, however, may be used in a limited way to make the link between freight flows, truck configurations, and additional costs for carriers if the use of liftable axles is constrained.

The methodology is described in what follows, with tables in Appendix M showing the actual computations. First, as described in Section 11, road-side surveys are used to construct a distribution of total tonnes hauled in each region by each configuration. Second, an index of cost per tonne is constructed for each configuration from the model described in Section 5. Costs per tonne for the T3 are set equal to 1.0 and all other costs are expressed as a percentage of this. The third step is to use the frequency distribution of tonnes given by the road-side survey to distribute to each configuration total annual (1987) tonnes of originating truck freight measured in Statistics Canada's surveys: 106 299 144 tonnes in the case of Ontario; 55 779 124 tonnes in the case of Quebec; and 20 448 510 tonnes in the case of Atlantic Canada. Having obtained a measure of annual tonnes by configuration, each of these numbers is then multiplied by its respective cost index. Those numbers are summed and a new frequency distribution of costs-per-tonne-times-total tonnes is obtained. Those percentages are then multiplied by Statistics Canada's 1987 measure of total operating expenses of carriers domiciled in each region: $5.5 billion in Ontario, $2.5 billion in Quebec, and $0.6 billion in Atlantic Canada. Table 12.1 shows the basic elements which serve as the bench mark for evaluating regulatory scenarios.

There are weaknesses in this methodology. Strictly, there is no relationship between Statistics Canada's survey of shipping documents, which measures freight flows according to origin or destination, and Statistics Canada's computation from a census survey of financial data which is based on a carrier's province of domicile. Further, the

measure of operating expenses includes activities not related to the movement of the tonnes of freight shown on Table 11.1: international activity; storage or warehousing; etc.

Table 12.1/ Trucking Costs and Configurations – total costs in millions of 1987 dollars

Vehicle Configuration	Ontario		Quebec		Atlantic Provinces	
	Percent of Costs	Total Trucking Costs	Percent of Costs	Total Trucking Costs	Percent of Costs	Total Trucking Costs
T3	1.5%	83.943	4.6%	115.977	5.7	48.907
T4,1L	0.2	8.877	0.0	0.000	0.0	0.000
T4	0.4	22.572	1.2	29.391	0.0	0.000
T3-2	0.1	4.080	0.3	7.709	1.1	9.331
T3-3	0.2	10.040	0.3	7.224	0.7	6.318
T3-4	0.2	11.120	0.3	7.398	0.3	2.328
T4-4,lL	0.1	6.368	0.0	0.000	0.0	0.000
3-S2	53.3	2959.922	29.8	753.232	51.1	435.147
3-S3	7.2	399.813	2.2	53.665	2.9	24.544
3-S3,1L	11.7	651.601	25.9	653.277	21.1	180.028
3-S4	2.8	153.111	0.0	0.000	0.0	0.000
3-S4,1L	1.7	94.004	12.2	307.461	0.0	0.000
3-S4,2L	3.1	171.643	0.0	0.000	0.0	0.000
3-S5,1L	0.9	50.290	0.0	0.000	0.0	0.000
3-S5,2L	1.2	64.129	0.0	0.000	0.0	0.000
3-S6,1L	0.3	9.955	0.0	0.000	0.0	0.000
3-S6,2L	0.3	14.556	0.0	0.000	0.0	0.000
3-S3-S2	5.8	319.224	4.3	109.200	5.4	46.351
3-S3-S2;1L	1.5	82.775	2.2	55.312	0.0	0.000
3-S2-3	0.5	29.669	1.0	26.258	1.0	8.758
others	7.3	406.404	15.8	398.543	10.6	89.959
	100.0	5554.096	100.0	2524.647	100.0	851.671

There are also some critical assumptions used in the analysis. Freight is arbitrarily divided into what has been called "rough" and "other" categories, with the assumption that the split is 30:70. "Rough freight," for lack of a better term, is used to describe those commodities where the characteristics of the haul allow the use of truck-plus-trailer configurations; there is no empirical data to verify the assumption of 30:70. It is critical as, often, the truck-plus-trailer used as an alternative to the liftable-axle configuration has the potential of lowering freight costs. Hence, the assumption of the

ratio 30:70 has a large effect on the magnitude of the overall impact of any of the scenarios. A sensitivity analysis for this assumption is contained in Appendix M.

Table 12.2/ Consequences of Scenario #2 – liftable axles = 8 tonnes

Vehicle Configuration	Ontario Actual costs	Ontario Additional costs Min.	Ontario Additional costs Max.	Quebec Actual costs	Quebec Additional costs Min.	Quebec Additional costs Max.	Atlantic Provinces Actual costs	Atlantic Provinces Additional costs Min.	Atlantic Provinces Additional costs Max.
T4,lL	8.9	0.2	0.4	--	--	--	--	--	--
3-S3,1L	651.6	-1.9	11.2	653.3	-0.6	9.7	180.0	-0.9	1.1
3-S4,lL	94.0	-0.9	0.8	307.5	0.2	3.2	--	--	--
3-S4.2L	171.6	-1.6	1.5	--	--	--	--	--	--
TOTAL		-4.3	13.9		-0.4	12.9		-0.9	1.1
% of total costs		-0.08	0.25		-0.02	0.51		-0.11	0.13

Table 12.3/ Conseuqnces of Scenario #3 – liftable axles = 6 tonnes

Vehicle Configuration	Ontario Actual costs	Ontario Additional costs Min.	Ontario Additional costs Max.	Quebec Actual costs	Quebec Additional costs Min.	Quebec Additional costs Max.	Atlantic Provinces Actual costs	Atlantic Provinces Additional costs Min,	Atlantic Provinces Additional costs Max.
T4,lL	8.9	0.4	0.7	--	--	--	--	--	--
3-S3,1L	651.6	-3.9	22.7	653.3	-1.3	19.7	180.0	-1.8	2.2
3-S4,lL	94.0	-1.8	1.7	307.5	0.5	6.4	--	--	--
3-S4.2L	171.6	-3.3	3.1	--	--	--	--	--	--
TOTAL		-8.6	28.2		-0.8	26.1		-1.8	2.2
% of total costs		-0.16	0.51		-0.03	1.03		-0.21	0.26

Table 12.4/ Consequences of Scenario #4 – no liftable axles

Vehicle Configuration	Ontario Actual costs	Ontario Additional costs Min.	Ontario Additional costs Max.	Quebec Actual costs	Quebec Additional costs Min.	Quebec Additional costs Max.	Atlantic Provinces Actual costs	Atlantic Provinces Additional costs Min.	Atlantic Provinces Additional costs Max.
T4,lL	8.9	0.4	0.7	--	--	--	--	--	--
3-S3,1L	651.6	-5.9	33.9	653.3	-2.0	29.4	180.0	-2.7	3.2
3-S4,lL	94.0	-4.5	4.2	307.4	1.2	16.0	--	--	--
3-S4,2L	171.6	-8.2	7.7	--	--	--	--	--	--
others	221.7	4.4	6.7	--	--	--	--	--	--
TOTAL		-13.8	53.2		-0.7	45.4		-2.7	3.2
% of total costs		-0.25	0.96		-0.03	1.80		-0.32	0.38

Table 12.5/ Consequences of Scenario #5 – one liftable axle per truck

Vehicle Configuration	Ontario Actual costs	Ontario Additional costs Min.	Ontario Additional costs Max.	Quebec Actual costs	Quebec Additional costs Min.	Quebec Additional costs Max.	Atlantic Provinces Actual costs	Atlantic Provinces Additional costs Min.	Atlantic Provinces Additional costs Max.
2L config.	250.3	15.0	52.6	--	--	--	--	--	--
TOTAL		15.05	52.6	--	--	--	--	--	--
% of total costs		0.27	0.95		--	--		--	--

The weaknesses in the methodology aside, the computations allow a rough estimate to be developed showing the macro impact of a change in policy on liftable axles.

Scenario #1 is the current situation (the "base case"). Configurations with liftable axles at current axle-load limits will continue to operate and the costs borne by each configuration are as shown in Table 12.1. The four other scenarios are evaluated as shown in Tables 12.2 to 12.5. The methodology is straightforward: the minimum/maximum change in costs (Tables 10.6 to 10.8) times the amount of freight affected (Tables 10.6 to 10.8) is multiplied by total annual trucking costs attributed to each configuration (Table 12.1). Where required, freight is assumed to consist of 30% "rough" (i.e., capable of being handled by truck-plus-trailers) and 70% "other."

Table 12.6 presents a summary of the changes in trucking costs in each region for each policy scenario. Scenario #4, in which liftable axles are banned, has the largest impact. As shown, this could be anywhere from a drop in trucking costs of $17.3 million to an increase in costs of $101.8 million, or, from -0.19 to +1.14% of total trucking costs in the three regions.

Table 12.6/ Summary of Incremental Costs of Scenarios

Scenarios	Ontario		Quebec		Atlantic		TOTAL	
	Min.	Max.	Min.	Max.	Min.	Max.		
Impact on Costs (millions of 1987 dollars)								
#2 $	-4.3	13.9	-0.4	12.9	-0.9	1.1	-5.6	27.9
#3 $	-8.7	28.2	-0.8	26.1	-1.8	2.2	-11.3	56.5
#4 $	-13.8	53.2	-0.7	45.4	-2.7	3.2	-17.2	101.8
#5 $	15.0	52.6	--	--	--	--	15.0	52.6
Percentage Impact (% of total trucking operating expenses)								
#2 %	-0.08	0.25	-0.02	0.51	0.11	0.13	-0.06	0.31
#3 %	-0.16	0.51	-0.03	1.03	-0.21	0.26	-0.13	0.63
#4 %	-0.25	0.96	-0.03	1.80	-0.32	0.38	-0.19	1.14
#5 %	0.27	0.95	--	--	--	--	0.17	0.59

13/ OPERATIONAL CONSIDERATIONS

The ability of various configurations to carry freight at a certain cost is only one factor determining how a trucker makes a decision to purchase new equipment. Other factors, or "operational considerations," are important to this analysis for the following reason. If all decisions were based on the relative hauling costs per tonne-kilometre, it would be difficult to explain the current proliferation of configurations. Why would not everyone use the same "lowest-cost" heavy-freight hauler? Therefore, because these operational considerations do enter into the decision-making process, their existence has to be recognized in a study attempting to provide insights on possible regulatory change. These other factors are discussed in what follows; many are inter-related.

Freight Characteristics: Some freight – for example, long sections of pipe or steel or other building products – is better-suited to tractor-semitrailer configurations than truck-plus-trailer or double-trailer configurations. Other freight – for example, dry bulk commodities which can be unloaded with hopper equipment – also tends to favour the use of semitrailers where there is enough room to fit the required equipment. As far as is known, for example, there are no straight trucks equipped with hopper mechanisms – at least any that are large enough for major unloading jobs.

Shipper Characteristics: Many shippers require equipment to be left at a loading/unloading dock for extended periods of time. This favours the use of tractors over straight trucks: the tractor can be used elsewhere while the trailers are being loaded or unloaded.

Terminal Characteristics: Some terminals or yards are not large enough to handle truck-plus-trailer or double-trailer configurations. For example, a terminal that can handle the pup trailers used in double-trailer configurations needs almost twice as many doors as one which is set up to handle 48-foot (or 53-foot) semitrailers. In other cases, a carrier's or a shipper's yard may not be wide enough to accommodate the turning manoeuvres of a double-trailer configuration.

Route Characteristics: Some routes – say an urban pick-up and delivery route, or a rural milk route – favour the use of straight trucks rather than tractor-semitrailers.

End-Point Characteristics: In some cases – for example, where the end point is a construction site – tractor-trailer equipment is not well-suited because of the problems of manoeuvrability. So, for example, bricks are generally delivered to construction sites (at least, residential construction sites) with a truck-plus-trailer so that the driver can take two loads into the site separately. The straight truck delivers its load first and then the load on the trailer is transferred onto the back of the truck for a second delivery. As another example, fuel being delivered to retail outlets sometimes has to be delivered in double-trailer configurations or short semitrailers because the longer (48-foot) tri-axle or quad-axle semitrailers cannot turn in the available space.

Industry Characteristics (or institutional arrangements): There is a range of other factors influencing the choice of equipment. For example, where owner-operators are used, there is a tendency to use tractor-semitrailer equipment rather than truck-plus-trailer equipment. Owner-operators own tractors; carriers or shippers own trailers.

Flexibility: The use of tractor-trailer equipment often provides the owner of the power unit (a carrier, a shipper or private trucker, or an owner-operator) with a greater degree of flexibility than would the use of a straight truck. The tractor can be used to pull any type of freight vehicle (van, reefer, flatdeck, etc.) whereas the straight truck is more or less bound to be used for the type of body installed.

It is not possible to factor all these operational considerations into the analysis of this research. However, the most important consequence of at least being aware of their existence is to be cautious in drawing sweeping conclusions about large-scale freight shifts from or to any of the three basic configurations: straight trucks-plus-trailers, tractor-semitrailers, and double-trailer combinations. This is the reason for the assumption employed in Section 10: there is a tendency for freight to shift from one configuration to another similar one.

Finally, there are several operational considerations that have not been mentioned and which cannot be incorporated into this discussion. Industry sources suggest that one of the advantages of equipment with liftable axles is the flexibility provided in loading heavy loads. Apparently, given the difficulty in spreading these loads over axles or axle groups, a semitrailer equipped with liftable axles provides certain abilities not available in semitrailers with fixed axles or axle groups. As noted in earlier sections, many of the larger configurations in Ontario had excess-axle-capacity and it may be this load-placement flexibility which accounts for a carrier's desire to have more axles than are required under the weight and dimension regulations. Drivers indicate the existence of liftable axles is an advantage in certain situations – mud, ice, off-road – where extra traction on the drive axles can be gained by raising the liftable axles. Drivers also note that configurations with liftable axles are much easier to manoeuvre around corners than comparable fixed-axle equipment. For this research, unfortunately, not enough is known about these subjects to allow their inclusion in the cost model.

14/ SUMMARY

In the 1960s Ontario developed the "Ontario Bridge Formula" as the controlling mechanism for weight and dimension regulations. Among other things, this permitted heavier loads to be carried by trucks of a given length, as the number of axles increased. The regulations do not limit the number of axles on a vehicle; nor do they limit vehicle configuration. The consequence has been a gradual increase in "multi-axle" trailers and 4-axle trucks. "Multi-axle" trailers have more than the two standard axles in a tandem-axle group. As these multi-axle vehicles are difficult to turn, the practice has been to make the additional axles liftable thereby allowing drivers to negotiate through sharp turns. There has been some experimentation with steerable axles as an alternative, but their use remains relatively rare.

Regulations in Quebec and Atlantic Canada are different from those in Ontario; however, they share one feature in the sense that they also allow higher GVWs for trailers with more than two axles. In Atlantic Canada, semitrailers are limited to three axles and, in Quebec, they are limited to four. The result has been the wide-spread use of 3-S3,1L equipment in Atlantic Canada; and, the wide-spread use of 3-S3,1L, 3-S4,1L, and (to a small extent) 3-S3-S2,1L configurations in Quebec.

Trucks – straight trucks, trucks-plus-trailers, tractor-semitrailers, and double-trailer combinations – with liftable axles now account for 27 to 31% of all truck freight tonnages in Eastern Canada. The imprecision is on account of the incomplete data sources available to make this estimate. The reason for the popularity of trucks with liftable axles is that payloads increase considerably for a small increase in either tare weight or operating costs. To pick just one example to show this, consider the Ontario 3-S3,1L – the most common liftable-axle configuration. The numbers below compare it with the 3-S2 – the most common large truck in Canada.

	3-S3,1L versus the 3-S2			
	% Increase in Tare Weight	% Increase in Payload	% Increase in Costs per km	% Decrease in Costs per tn/km
Van	6.9	34.1	10.7	-17.4
Refrigerated	6.5	39.5	10.0	-21.2
Flatdeck	8.7	32.2	10.2	-16.6
Tank	16.4	28.0	9.9	-14.1
Dump	5.7	34.9	8.7	-19.3
Hopper	5.7	34.9	7.6	-20.2
Log	9.2	32.1	6.8	-19.2

These comparisons are based on one particular set of axle loads ("high"), one set of assumptions about tare weight ("heavy"), and a whole range of assumptions and/or parameters for the costing model (for example, costs are calculated for a 160 km trip).

Change any of these variables and the comparisons also change. The point is, though, that – except under extreme circumstances – they will always show the same relative advantage of the 3-S3,1L over the 3-S2. Similarly, comparisons in Quebec and Atlantic Canada show that the 3-S3,1L increases payloads by about one-third while increasing operating costs per kilometre by only 5 to 8% and decreasing freight costs by between 14 and 22%.

It might be asked why a carrier would not simply opt for a 3-S3 (instead of a 3-S3,1L) if payloads larger than those possible on a 3-S2 were desirable. A 3-S3, like the 3-S3,1L, is a 6-axle tractor-semitrailer. The difference is that it uses three fixed axles ("tridem") on the semitrailer rather than a tandem-plus-liftable axle group ("tri-axle"). The explanation is simple: a 3-S3 generally has a smaller payload than the 3-S3,1L because of lower loads allowed on a tridem in comparison to a tri-axle, and it often has higher operating costs per kilometre. There is another reason why the 3-S3,1L is preferred: it can be used as a 3-S2 with the liftable axle raised. This is important for carriers using equipment on domestic and international operations. In the United States – particularly on interstate highways – trucks cannot use tridem axles to gain any weight advantage.

So, where competitive conditions require carriers to use equipment with the potential to haul heavy, dense freight at as low a cost as possible, the incentive to use trucks with liftable axles is high in eastern Canada. Particular characteristics of the freight or the nature of the haul dictate the particular liftable-axle configuration chosen: a truck-plus-trailer, a tractor-semitrailer, or a double-trailer configuration.

Over the last few decades shippers in eastern Canada have benefitted from weight and dimension regulations in that, through the tolerance of liftable-axle equipment, they have enjoyed the lower hauling rates such equipment allows. The eastern provinces, however, have concerns about the performance of liftable axles. They suggest liftable axles reduce a truck's stability in some situations; they feel they make enforcement of axle-load regulations difficult; and, as a result of the difficulties with enforcement, they believe liftable axles may pose a threat to pavements and bridges. The agreement reached by Canadian provinces and territories in 1988 to establish uniform national weight and dimension regulations for specified roads and specified configurations recognized the deficiencies of liftable axles. As a result, the agreement does not allow them on any configuration – RTAC configurations – it recognizes. Provinces are free, however, to continue to have their own regulations which already permit liftable-axle equipment.

Provinces from Ontario east, in the meantime, are reviewing their positions on liftable axles. This study, as part of that review, has analyzed the economic and operational consequences of five of a long list of possible regulatory options. It has not considered the effect of liftable axles on highway infrastructure or highway safety. The options ("scenarios") evaluated are:

#1: current truck configurations with liftable axles at current axle-load limits.
#2: liftable axles held to a maximum of 8 tonnes.
#3: liftable axles held to a maximum of 6 tonnes.
#4: liftable axles banned.
#5: liftable axles allowed at current loads, but restricted to one liftable axle per truck or tractor-semitrailer combination.

The first step in this analysis is the development of a costing model capable of distinguishing the hauling costs of a wide variety of different trucks with all factors except configuration held constant. In the real world, a large number of configurations actually haul freight at quite similar cost, given the right combination of circumstances. The point of this analysis, however, is to hold as many factors constant as possible, and to examine only the intrinsic differences in costs among different configurations. In other words, there is no point comparing a 3-S3,1L with a 3-S3 if the former operates with high labour costs, poor fuel consumption, in a situation where there are long waits for loading and unloading, and where any of a hundred other factors differ. The comparison required here is to have everything except the two different axle arrangements held constant. Under these circumstances, and only under these circumstances, is it possible to develop observations on the factors surrounding the use of liftable axles.

What the first part of the analysis shows is that there are a number of configurations without liftable axles that are capable of hauling freight at costs close to – in some cases lower than – trucks with liftable axles. The following is an over-simplification of what, in actual practice, is hundreds and hundreds of permutations:

- the T4,1L — In Ontario, the T4 (tandem-steer) hauls freight at a cost of about 4 to 8% higher than the T4,1L.

- the T4-4,1L — In Ontario, the T3-4 can often haul freight at the same cost as the T4-4,1L. In fact, some carriers operate both T3-4 and T4-4,1L equipment and indicate there is little hauling cost differences between the two. They sometimes suggest, though, that the T4-4,1L with its excess axle-load capacity has a slight advantage in terms of the care needed to position loads on the equipment properly (i.e., to achieve the correct axle-load distribution).

- the 3-S3,1L — There are many substitutes for the 3-S3,1L. In all three regions, the T3-4 or the T3-3 can actually haul freight at a lower cost than the 3-S3,1L. Of course, its use is only possible where the characteristics of the haul allow the use of truck-plus-trailer equipment rather than tractor-semitrailers. Where this is not possible, the 3-S3 can be used – either with "local" tridems or – what is almost the same thing in many cases – the "RTAC" tridem. Generally, the 3-S3 can haul freight at a cost of 5 to 10% higher than the 3-S3,1L. Finally, in Ontario and Quebec, under

Scenario #2 and #3, the 3-S4,1L is an ideal substitute for the 3-S3,1L in that it preserves payload size and also keeps hauling costs per tonne-kilometre at almost the same level as the 3-S3,1L.

- the 3-S4,1L & 3-S4,2L — For some freight – that labelled for "rough" in the preceding sections – the T3-4 is a logical substitute in that it can actually haul freight at a lower cost – 8 to 13% lower – than the 7-axle tractor-semitrailer. For freight where the characteristics of the haul are not amenable to the use of truck-plus-trailers, the most likely substitute is the B-train, which can haul freight at a cost of 3 to 13% higher than the 7-axle tractor-semitrailer.

- other multiple-axle equipment

  Most of the remaining multi-axle semitrailers (which only operate in Ontario) could be replaced by the B-train. B-trains can generally haul freight at a cost of anywhere from 6 to 21% higher than the 8- and 9-axle tractor-semitrailers. (The 21% is an extremity which may not actually arise in the real world.)

This first part of the analysis is used to draw up a series of predictions as to what would happen under each scenario. The predictions are based on several components:

a) The comparison of hauling costs developed in the cost model.

b) The assumption that, because of operational considerations, there is a tendency for freight to shift from one type of configuration to another similar configuration (a straight truck to a straight truck, a tractor-semitrailer to a tractor-semitrailer, etc.).

c) An assumption that some freight now moving on tractor-semitrailers would in fact shift to truck-plus-trailer configurations as the results of various regulatory options that have made the hauling costs of these trucks increasingly attractive.

d) A prediction as to how much of the total freight carried by any particular configuration would be affected under each of the regulatory scenarios.

Since there are unknown elements in these predictions, a large degree of latitude is given to the "low" and "high" estimates of industry-wide cost impacts. The impacts of various assumptions also are tested in a sensitivity analysis. With this latitude in the estimates, and after testing the sensitivity of the assumptions, the following numbers show the most reasonable estimate of the impact of the scenarios. No transition, or "change-over" costs are included in these figures. Such costs are difficult to estimate and, in any case, depend on the procedures used to implement new regulations.

	Industry Operating Expenses (millions of 1987 dollars)	Percent Change
#1 base case (current regulations)	8 930.4	----
#2 liftable axles = 8 tonnes	-5.6 to 27.9	-0.06% 0.31%
#3 liftable axles = 6 tonnes	-11.3 to 56.5	-0.13% 0.63%
#4 no liftable axles	-17.2 to 101.8	-0.19% 1.14%
#5 one liftable axle/truck	15.0 to 52.6	0.17% 0.59%

Banning liftable axles has the greatest impact; Scenarios #3 and #5 are roughly comparable in terms of impact; and, Scenario #2 has the smallest overall impact. Another inescapable conclusion is that none of the scenarios amount to a large impact in terms of total trucking costs. In fact, under Scenarios #2 through #4 there is even a possibility that trucking costs would fall by a small amount – at least to the extent that a change encouraged freight to shift from tractor-semitrailers to truck-plus-trailer equipment. Because it is hard to predict just how much freight would shift, it is not possible to be definite about this possibility of lower trucking costs. More likely, the actual impact would be somewhere in between the two numbers given above for each scenario – that is, somewhere on the "plus" side (cost increase) of the ledger. These increases could range anywhere from a few million to as much as a hundred million dollars. But even a hundred million dollars is a little more than one percent of total industry costs.

While the conclusion that the policies examined here do not give rise to large changes in total industry costs remains valid, a qualification must be noted. The numbers used to derive the above estimates suggest that some individual operations may be affected by as much as a 21% increase in hauling costs; this, admittedly, is an extreme value – that is, it is the outside limit for a case that may not occur very frequently, if at all. But, there may well be situations where costs increase by 10 to 12%. For these operators, or for the shippers served, the conclusion that the industry-wide impact is small must appear to be a small consolation. The policy issue, in these cases, is the trade-off between the increase in trucking costs that some carriers and/or shippers will experience, versus the decrease in infrastructure costs (pavements, bridges) and/or increase in highway safety (stability) that a change in a policy brings about. The trucking costs have been the subject of this research; an evaluation of all the trade-offs must remain the responsibility of others.

APPENDIX A/ CONFIGURATIONS

A.1/ Introduction

This appendix contains a description of information developed on 24 basic, 53 regional, and 371 regional-body-style configurations. For example, a 7-axle truck-plus-trailer dump in Ontario is described as well as an 8-axle RTAC C-train tanker in Atlantic Canada. Some of these configurations may be more or less important than others. For example, it may be that there is no such thing as a T4-4, 1L logging truck. For the sake of completeness, however, each of the 24 configurations is analyzed for all seven body styles.

A.2/ Weight and Dimension Regulations

Provinces in eastern Canada are in the process of amending their weight and dimension regulations governing large trucks. The process involves the implementation of the RTAC Memorandum of Understanding on Vehicle Weights and Dimensions agreed to on February 12, 1988 and the further regulations agreed to in September, 1989. Strictly, these are not "RTAC" regulations; however, for convenience they are referred to as such here. The reference point for the regulations is the chart shown in the November 1989 issue of *Motor Truck*. This information has been discussed with all provinces and RTAC (in October, 1989, in conjunction with the preparation of the chart). Additional points to note about the regulations as they are used here are:

- Minimum required axle spacings have been assumed. That is, for any of the trucks for which costs are developed, it is assumed that the required spacings – whether Ontario, Quebec, Atlantic, or RTAC – are met.

- The possible changes in length limits in Ontario are not critical to this research. These affect primarily the facility of using RTAC B-trains (25 metres) and the hauling of low-density general freight (53-feet, semitrailers).

- The RTAC C-train is not an important truck in eastern Canada. Nevertheless, it has been included because of the possible changes that might increase its importance. For this analysis, it is assumed it would be allowed to operate on all roads at 58.5 tonnes (current RTAC limit is 53.5 t) and with a box length of 18.8 metres (currently 18.5 m) allowing, for example, two 29-foot pup trailers. This assumption may be unrealistic or premature: it is not known if Quebec and Atlantic Canada will allow it at 58.5 tonnes on other than major roads.

- Several recent changes to Quebec regulations have been incorporated in the analysis: 3-S4, 1L configurations have had their maximum GVW reduced from 57.5 to 55.0 tonnes; B-trains on non-designated roads (i.e., other than 4-lane, divided highways and several other roads) have had their maximum GVW increased to 59.0 tonnes (the 62.5 t RTAC B-train is limited to the designated roads); and the maximum

load on quad axles, given certain spread conditions, has been increased from 30 to 32 tonnes.

A.3/ Axle Loads

With the regulations and the qualifying notes described in the preceding section, Table A.1 shows axle loads used in this analysis. These are a blend of maximums allowed under the regulations, those allowed in some cases given the most common axle-spreads, and, in some other cases such as front-steering axles, given the characteristics of typical tractors. Judgement has been used in some cases. To guide this judgement, the results of a survey by the Ontario Ministry of Transportation in August 1989 are used (Appendix B). This provides information on such things as the front-axle loads, common spreads, etc. Admittedly the trucks surveyed hauled only one commodity – gravel – but this is the only information readily available and it is assumed to be relevant for other configurations. Other points to note about Table A.1 are:

- Maximums loads are those allowed in the relevant regulations in all cases except combination front steering axles.

- Front steering axles of 5.0 tonnes are assumed to be the heaviest practical loads in many cases; this is the "high" load shown on the table. For maximums, it assumed that 7.0 tonnes is the practical maximum, particularly given the common wheelbases and typical axle setbacks in use (see Table B.1).

- Straight trucks are assumed to operate with steering axles in the range of 7.0 tonnes (see Table B.1); the maximums shown comply with the regulations (although the figure for Atlantic Canada has been rounded).

- In Atlantic Canada, while regulations show maximum GVWs with combination front axles at 4.5 tonnes, there is nothing limiting these to anything less than the single-axle maximums (9.1 t). In most cases these additional front-axle loads can be added to GVWs as long as the total does not exceed the relevant maximum (in New Brunswick, this varies by road class; in Nova Scotia it is 50.0 t). On Table A.1, 7.0 tonnes is assumed to be the maximum front-axle load, which is in accord with the assumptions used for Ontario and Quebec.

- The high drive tandem axle loads assume spreads of 1.52 metres (60"); the high trailer tandem axle loads assume spreads of at least 1.83 metres (72") (see Table B.1).

- The high tridem-axle loads assume a spread of 3.65 metres (144"). This is one case where the assumption does not correspond well with information shown on Table B.1. For RTAC tridems, the high load figure assumes a spread of 3.04 metres (120").

Table A.1/ Heavy Truck Axle Loads – tonnes

		Ontario	Quebec	Atlantic
Steering				
tandem	max	18.0	17.5	x
	high	16.0	16.0	x
truck	max	9.0	8.5	9.0
	high	7.0	7.0	7.0
combination	max	7.0	7.0	7.0
	high	5.0	5.0	5.0
RTAC	max	5.5	5.5	5.5
	high	5.0	5.0	5.0
Single non-liftable	max	10.0	10.0	9.1
	high	9.0	9.0	9.0
Single liftable				
Scenario #1		10.0	10.0	9.0
Scenario #2		8.0	8.0	8.0
Scenario #3		6.0	6.0	6.0
Scenario #4		0.0	0.0	0.0
Scenario #5		10.0	10.0	9.0
Tandem				
power unit	max	19.1	20.0	17.0
	high	17.9	18.0	17.0
trailer	max	19.1	20.0	18.0
	high	19.1	19.0	18.0
RTAC	max/high	17.0	17.0	17.0
Tridem	max	28.6	30.0	27.0
	high	24.4	23.0	25.0
RTAC	max	24.0	24.0	24.0
	high	23.0	23.0	23.0
	B-train	23.0	23.0	23.0
Quad axle	max	40.0	32.0	x
	high	38.0	30.0	x

- RTAC loads are assumed to be those agreed to in the February 1988 agreement. In fact, provinces in eastern Canada will allow somewhat higher weights. The point, however, of holding the axle loads to the RTAC values is simply to compare truck costs of RTAC and non-RTAC trucks.

A.4/ Lotus Program

A Lotus 123 spreadsheet calculates GVWs for 53 regional configurations under both the maximum and high axle-load assumptions, and the maximum and high payloads for 371 regional-body-style configurations.

- **Inputs:** Inputs are (i) axle loads shown on Table A.1; (ii) tare weights discussed in Appendix C and summarized in Table 4.1 of Section 4; and (iii) specified liftable-axle loads.

- **Structure:** The program is organized into three basic columns for each of the three regions, and 24 secondary columns for each of the configurations. Some configurations are omitted in some regions as shown in Tables 3.1 through 3.5. Finally, there are two columns for each configuration: one for maximum and one for high axle loads. The result is 106 columns. The rows are organized as follows: (i) the first series of rows correspond to axle groups – the number varying from one configuration to another; (ii) the next row sums axle-group loads; (iii) the next row shows the GVW cap given the regulations in each region and given the front axle load and the assumed required axle spacings; (iv) the next row contains an instruction determining which of the two preceding rows is the actual GVW; and (v) the next series of 14 rows contain calculated tare weights and payloads for each body style.

- **Maximum GVWs:** The program has been written such that when liftable axles are set equal to zero – that is, for the regulatory scenario where liftable axles are banned – the GVW calculation takes into account the fact that there is one less axle. So, for example, a 3-S4, 1L now becomes a 3-S3 as far as the "GVW cap" is important to the calculation.

- **Number of payloads calculated:** There are four payloads for each of the 378 regional-body-style configurations: two axle-load scenarios (maximum and high) and two assumptions about tare weights. However, for simplicity, only two payloads are actually calculated: (i) the maximum GVW minus the minimum tare weight yields the highest payload possible (a rare event in the real world), and (ii) the high GVW minus the high tare-weight yields what might be considered a typically high payload.

APPENDIX B/ EMPIRICAL DATA ON VEHICLE CHARACTERISTICS

In August 1989, the Ontario Ministry of Transportation conducted a survey of gravel trucks measuring such things as axle loads and other characteristics of loaded gravel trucks some months after a moratorium on axle load enforcement had gone into effect. A disk with some of the data has been made available for this research. The interest is to document such things as typical front-axle loads on heavy trucks in Ontario (this is critical in determining typical GVWs and, hence, typical heavy payloads), typical drive-tandem spreads, typical trailer-tandem spreads, and so on. It is on the basis of this information that the high axle loads in Appendix A have been determined. This source is also used to some extent to infer characteristics about trucks in other provinces. Relevant data from this survey is shown in Table B.1.

Table B.1/ MTO Survey of Loaded Gravel Trucks

Configuration	Sample	Mean Axle loads (kg) & Coefficients of Variation ()				
		front	drive tandem	trailer tandem	trailer tridem	air-lift
T3	41	6 951 (14.7%)	18 770 (6.6%)			
T4	52	7 223 (15.3%)	20 012 (8.0%)			6 641 (32.6%)
3-S2	10	4 857 (7.6%)	17 446 (11.0%)	18 124 (11.3%)		
3-S3	180	5 121 (9.3%)	17 290 (10.2%)	19 221 (12.0%)		9 253 (17.6%)
3-S4	24	5 217 (10.8%)	16 928 (8.8%)		21 530 (8.0%)	9 707 (9.9%)
Total	307	5 720 (20.3%)	17 926 (11.3%)	19 163 (12.0%)	21 530 (8.0%)	8 765 (23.0%)

	Mean Axle Spreads (m) & Coefficients of Variation ()		
	drive tandem	trailer tandem	trailer tridem
307	1.54 (5.0%)		
190		1.82 (8.7%)	
24			2.73 (12.2%)

APPENDIX C/ TARE WEIGHTS

Information on tare weights has been collected from a variety of sources, including previous research for the Ontario Ministry of Transportation in 1987 and for the Transportation Development Centre in 1986 [4]. This has been combined with information provided by a number of trailer and tractor manufacturers: Raglan Welding Shop Ltd., Oshawa (dump, and hopper-bottom equipment); Cobra Manufacturing Inc., Georgetown (dump); Mond Industries Ltd., Toronto (refrigerated trailers); Manac, Ontario and Quebec (vans, flatdecks, log); Hutchinson Industries, Toronto (tanks); Mack Trucks, Oakville (trucks); Whelan Motors, Ottawa (dollies). Other sources, for example, advertisements in trade magazines or brief telephone conversations included McLeave International (dump trucks), Titan Trailers (dump pony trailers), and a log trailer manufacturer.

Everyone contacted stressed that weights depend on a wide number of factors. For example, considering tank trailers, the total weight of two tandem-axle trailers might differ considerably depending on such things as the suspension system, the number of compartments, the number of valves, and a variety of other factors. When asked for the "typical" weight of a tandem-axle refrigerated trailer, respondents suggested the answer could vary by as much as 2.3 tonnes depending on the precise specifications ordered by the customer – extra "I" beams, various thicknesses of insulation, the type of floor, etc. The result is that the figures shown in Table C.1 are to be considered as a "typical" range of equipment weights; there may trucks that fall outside this range. As the source data were collected in imperial units, Table C.1 also shows the information in this manner; the calculated tare weights – Table 4.1 – have been converted to kilograms. Some of the equipment – for example, the 3-axle truck with a hopper – may not exist; however, for computational reasons it was easier to use cost programs that had complete matrices of information.

Table C.1/ Tare Weights – pounds

Tractor	from	17 500 to 20 000
A-dolly		5 000
C-dolly		4 000
B-train lead		1 000 (i.e., additional weight of a trailer used as a lead in a B-train)
Fixed axle	from	2 400 to 2 800
Liftable axle	from	2 200 to 2 800

		Van	Reefer	Flat	Tank	Dump	Hopper	log
3-axle truck	from	19 500	24 000	18 000	20 000	19 184	20 000	19 000
	to	20 500	26 000	19 000	22 500	22 000	22 000	21 000
2-axle pup	from	10 000	15 000	9 000	11 000	11 000	11 000	10 500
	to	11 500	20 000	11 000	13 000	12 000	12 000	11 000
3-axle pup	from	12 500	18 000	11 500	12 300	13 230	13 230	13 500
	to	14 000	23 000	13 500	13 500	18 302	18 302	14 000
2-axle semi	from	13 000	20 000	11 500	12 500	14 000	11 687	13 000
	to	15 000	24 000	13 000	13 500	15 000	14 994	13 500
3-axle semi	from	15 500	23 000	14 500	18 000	16 000	16 000	16 000
	to	17 500	27 000	16 000	19 000	17 000	17 000	16 500
4-axle semi	from	18 000	26 000	17 500	20 500	18 000	22 050	19 000
	to	20 000	30 000	19 000	21 500	20 948	23 373	19 500

APPENDIX D/ FUEL CONSUMPTION

Trimac's implicit fuel consumption relationships, calculated as the fuel cost per kilometre divided by the fuel price per litre, are shown in Table D.1. They do not generally reflect the lower GVWs in New Brunswick in comparison to Ontario or Quebec. They do reflect, to some extent, the increasing GVWs within a region, although there is little difference between the 5-axle tractor-semitrailers and the 7/8-axle doubles.

Table D.1/ Analysis of Trimac Fuel Consumption

		Ont	Que	NB
GVW (tonnes)	2-axle	19.0	18.5	14.5
	5-axle	47.2	48.5	40.5
	7/8-axle	63.5	57.5	56.5
Fuel consumption (L/100 km)				
2-axle	Dry Freight	25.6	25.7	25.7
	Bulk	26.3	26.2	25.7
5-axle	Dry Freight	41.5	41.6	41.5
	Bulk	43.4	43.4	43.4
7/8-axle	Dry Freight	43.4	43.4	43.4
	Bulk	44.9	44.9	44.7

The Trimac data result in an estimate of the relationship between fuel consumption and gross weight as follows:

$$L/km = 4.433 - 0.039 * GVW$$

By way of comparison, Clayton develops the following relationships using 1983 data on actual fleet fuel consumption experience (Western Canada) [5]:

$$km/L = 2.65 - 0.0207 * GVW$$

Clayton's "spring/fall" equation produces fuel consumption rates quite different from Trimac's – they are much higher (i.e., km/L are lower) and the slope of the curve relating fuel consumption to GVW is not as steep.

A third source, is the 1989 results of Ontario's "Drive$ave/Trucksave" Fuel Economy Challenge [6]. All data from this source have been analyzed for four configurations: tractor-semitrailer vans, tractor-semitrailer dumps, tractor-semitrailer flatdecks, and tractor-semitrailer dumps. There were not enough straight trucks to include them as a separate category. The "tractor-semitrailer" category obviously included double-trailer

combinations, but these could not be identified from the source data. The results of this analysis are shown in Table D.2. They tend to under-estimate fuel consumption of typical large trucks in that they are based on a competition in which drivers were making an effort to conserve fuel and in that they do not include any city driving.

Table D.2/ Ontario Drive$ave/Trucksave Fuel Consumption – 1989

	# observations	Estimated Fuel Consumption (km/L)	R^2
Van	215	3.473 - 0.022 (GVW)	0.15
Flatdeck	21	2.879 - 0.012 (GVW)	0.23
Tank	65	3.893 - 0.031 (GVW)	0.46
Dump	17	3.599 - 0.026 (GVW)	0.58

As indicated by the low R^2's on Table D.2, there are clearly variables other than weight important for fuel consumption. However, as weight is the variable affected by the regulatory scenarios under consideration here, it is only this relationship that has to be built into the costing model. For here, then, the above equations are used to develop fuel costs per kilometre, with the first equation used for vans and reefers, the second for flatdecks, the third for tanks, and the third for dumps, hoppers, and logging trucks.

Figure D.1 shows these four functions and Figure D.2 shows them in comparison to Trimac's (the highest curve) and Clayton's (the lowest curve).

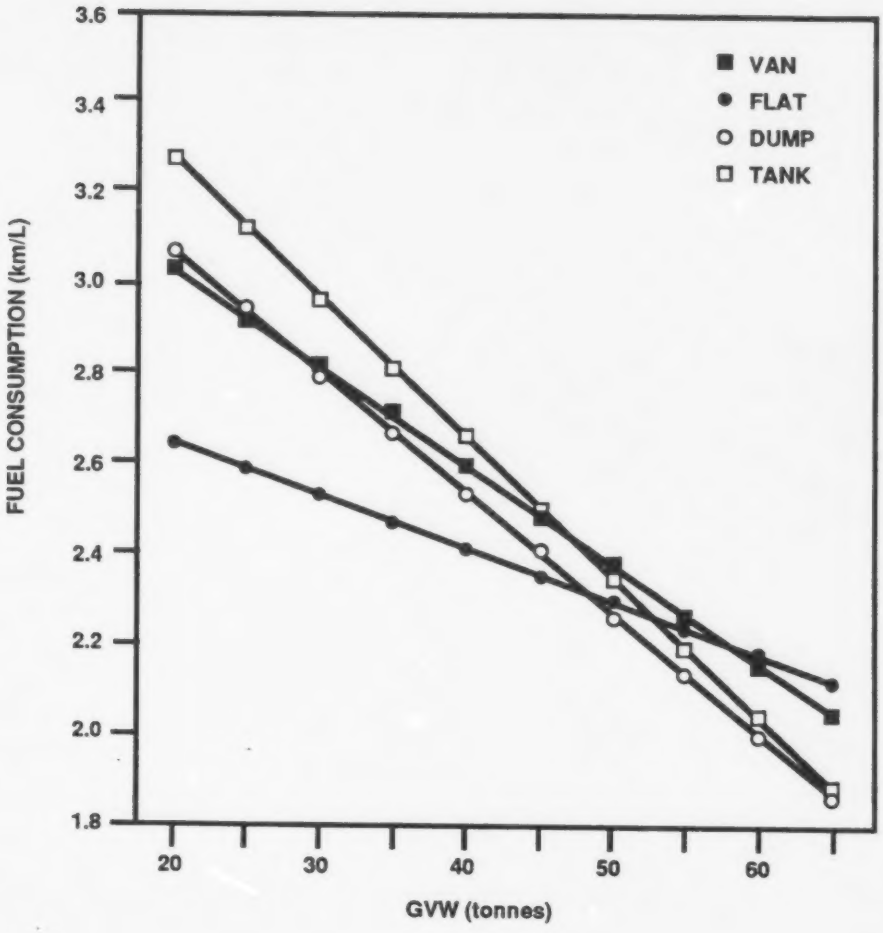

Figure D.1/ Ontario "Drive$ave/Trucksave" Data

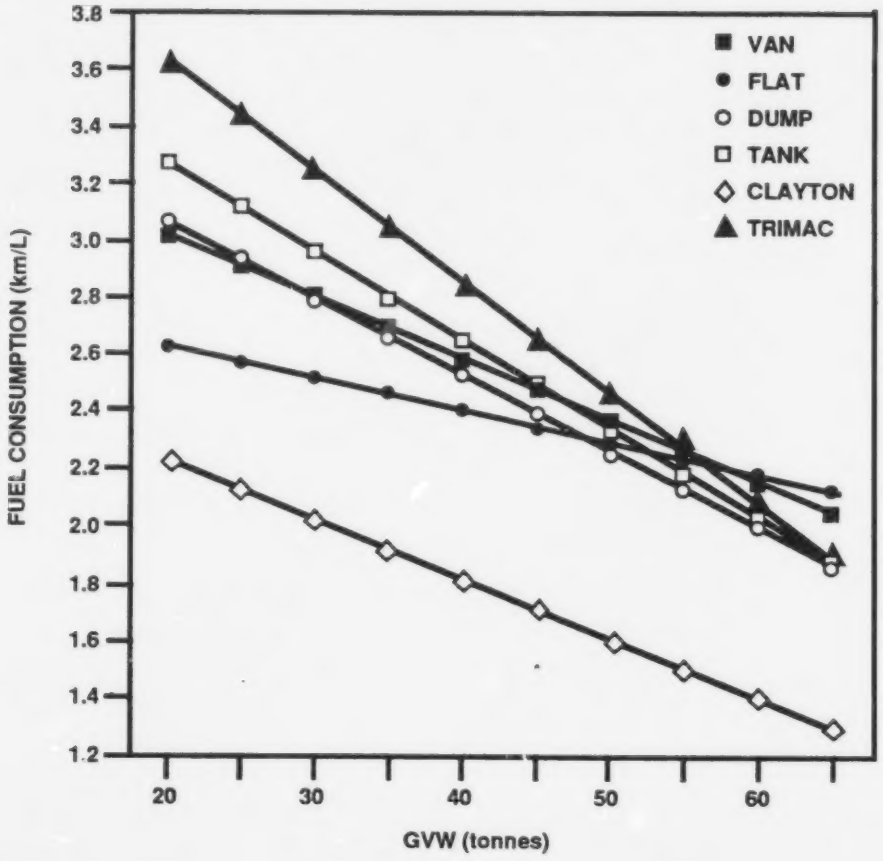

Figure D.2/ Ontario vs Clayton and Trimac

APPENDIX E/ EQUIPMENT PRICES

Two aspects of Trimac data are used for equipment prices. First, the prices shown for tractors – the ones used with the lighter 5-axle equipment and the ones used for the heavier, bulk equipment – are as given by Trimac. In this analysis the dividing line of 7-axles is used; anything with less than 7-axles is given the lower-cost tractor. Tractor prices, therefore, are as follows:

	Ontario	Quebec	Atlantic
Tractor (less than 7-axle combination)	109 860	110 418	113 033
Tractor (7 or more axle combination)	113 856	114 888	116 952

Second, the differential in equipment prices between the three regions is used in the cost model to establish prices for each region. For that reason, the information in Table E.1 contains only Ontario prices. Equipment prices in Quebec are roughly 0.75% higher than in Ontario and prices in New Brunswick are roughly 2.7% higher than in Ontario.

The information shown on the table was collected from a variety of trailer and truck manufacturers: Raglan Welding Shop Ltd., Oshawa (dump, and hopper-bottom equipment); Cobra Manufacturing Inc., Georgetown (dump); Mond Industries Ltd., Toronto (refrigerated trailers); Manac, Ontario and Quebec (vans, flatdecks, log); Hutchinson Industries, Toronto (tanks); Mack Trucks, Oakville (trucks); Whelan Motors, Ottawa (dollies). Other sources included advertisements in trade magazines. It is a range of reasonable prices, not an average based on a survey. Some equipment – for example, trucks with a hopper – may not exist; however, for computational reasons it was easier to use complete matrices of information.

Table E.1/ Ontario Equipment Price Matrix

	Van	Reefer	Flat	Tank	Dump	Hopper	Log
T3	113 400	140 400	113 400	129 600	86 400	86 400	86 400
T4, 1L	118 800	145 800	118 800	135 000	91 800	91 800	91 800
T4	132 600	159 600	132 600	148 800	105 600	105 600	105 600
2-axle semi	23 200	54 000	16 700	64 800	37 300	25 400	20 800
3-axle semi	26 500	60 500	21 100	88 600	51 800	33 500	25 100
4-axle semi	30 800	67 000	25 400	102 600	57 200	42 100	29 400
axle	5 400	5 400	5 400	5 400	5 400	5 400	5 400
A-train (8)	47 500	116 600	38 900	118 800	86 400	59 400	52 400
B-train (7)	42 100	111 200	33 500	113 400	81 000	54 000	47 000
B-train (8)	46 400	116 600	38 900	140 400	84 800	62 100	51 300
C-train (8)	52 900	122 000	44 300	124 200	91 800	64 800	57 800
2-axle pup	18 400	52 900	14 000	54 000	37 800	24 300	20 800
3-axle pup	22 700	58 300	19 400	81 000	41 600	32 400	25 100

APPENDIX F/ REGISTRATION FEES

On the basis of information from Ontario, Quebec, and New Brunswick, Table F.1 shows registration fees used in this analysis. Only those relevant to GVWs shown on Tables 3.1 to 3.5 are shown. The weight categories should be read, for example, as 24 001 kg to 25 000 kg.

Table F.1/ Vehicle Registration Fees

	Annual Registration Fee, Power Unit and Trailer		
	Ontario	New Brunswick	Quebec
Tonnes			
- 24	$ 937	$ 918	3-axles - $ 850
24 - 25	981	955	4-axles - 1 250
25 - 26	1024	989	5-axles - 1 700
27 - 28	1112	1076	6-axles+ - 2 300
28 - 29	1156	1111	
30 - 31	1244	1180	
32 - 33	1332	1267	
33 - 34	1376	1302	
34 - 35	1421	1336	
36 - 37	1510	1421	
37 - 38	1554	1456	
39 - 40	1664	1527	
41 - 42	1734	1612	
42 - 43	1779	1649	
43 - 44	1824	1684	
44 - 45	1869	1718	
45 - 46	1915	1753	
46 - 47	1960	1803	
47 - 48	2006	1838	
48 - 49	2051	1872	
49 - 50	2097	1907	
50 - 51	2142	1941	
51 - 52	2188	1996	
52 - 53	2234	2031	
53 - 54	2280	2065	
54 - 55	2326	2100	
55 - 56	2372	2134	
56 - 57	2419	2168	
57 - 58	2465	2202	
58 - 59	2511	2236	
59 - 60	2558	2270	
60 - 61	2604	2304	
61 - 62	2651	2338	
62 - 63	2698	2355	
63 - 64	2722		

APPENDIX G/ MAINTENANCE COSTS

Trimac maintenance costs are shown in Table G.1. It is to be noted that the costs (cents/km) increase for trailers with more axles:

	Ontario	Quebec	New Brunswick
Difference in maintenance cost/km between 5-axle and 7/8-axle trailers:			
dry freight	1.3	0.6	1.6
bulk	1.2	0.7	1.6
Increase in # axles	2	3	2
implicit maintenance cost/axle (average)	0.625	0.217	0.800

For here, then, a cost of 0.5 cents per kilometre per axle is used for any trailer over the basic 2-axle.

Using Trimac's "dry freight" and "bulk" trailers as a method of distinguishing between trailer styles, using the assumed cost of $0.005 per axle, and using the further assumed cost of $0.005 per liftable axle, the maintenance costs used in the cost model are shown in Table 6.1.

Table G.1/ Trimac Maintenance Costs

Maintenance Costs per Kilometre (cents)

		Ontario	Quebec	New Brunswick
2-axle diesel truck				
Dry Freight		12.6	12.1	13.9
Bulk		14.7	14.7	14.4
5-axle tractor-semitrailer				
Dry Freight	- power unit	12.1	12.2	11.6
	- trailer	5.7	6.0	5.1
Bulk	- power unit	12.1	12.2	11.6
	- trailer	7.7	7.7	6.3
7/8-axle train				
Dry Freight	- power unit	14.3	14.5	13.9
	- trailer	7.0	6.6	6.7
Bulk	- power unit	14.3	14.5	13.9
	- trailer	8.9	8.4	7.9

APPENDIX H/ TIRE COSTS

Tire costs used in Trimac's procedures are shown in Table H.1. As with maintenance costs, they increase for trailers with more axles:

	Ontario	Quebec	New Brunswick
Difference in tire cost/km between 5-axle and 7/8-axle trailers:	0.3	0.6	0.4
Increase in # axles	2	3	2
implicit tire cost/axle (average)	0.15	0.20	0.20

For here, then, a figure of 0.2 cents per kilometre per axle is used for trailers with more than two axles. Using Trimac's tire costs as a base, the costs used in the cost model are shown in Table 6.2.

Table H.1/ Trimac Tire Costs

Tire Costs per Kilometre (cents)

		Ontario	Quebec	New Brunswick
2-axle diesel truck				
Dry Freight		4.0	4.0	3.9
Bulk		4.0	4.0	3.9
5-axle tractor-semitrailer				
Dry Freight	- power unit	2.9	2.8	2.5
	- trailer	2.9	2.9	2.1
Bulk	- power unit	2.9	2.8	2.5
	- trailer	2.9	2.9	2.1
7/8-axle train				
Dry Freight	- power unit	3.2	3.4	2.9
	- trailer	3.4	3.6	3.8
Bulk	- power unit	3.2	3.4	2.9
	- trailer	3.4	3.6	3.8

APPENDIX I/ TRANSPORT COSTS

"Transport" costs used by Trimac are shown in Table I.1. For this analysis, "bulk truck" figures are used for all trucks (whether or not they haul trailers), and the "tractor" figures shown for either a dry freight or a bulk train are used for all tractors. For trailers, the amounts shown for a dry freight 5-axle combination are used for van and flatdeck trailers, while the amounts shown for bulk trailers in a train are used for all other trailers.

Table I.1/ Trimac "Transport" Costs

Annual Transport Costs (dollars)

		Ontario	Quebec	New Brunswick
2-axle diesel truck				
Dry Freight		0	0	0
Bulk		489	380	434
5-axle tractor-semitrailer				
Dry Freight	- power unit	1954	2389	2063
	- trailer	1629	1520	1086
Bulk	- power unit	1954	2389	2063
	- trailer	1846	2497	977
7/8-axle train				
Dry Freight	- power unit	1954	2389	2171
	- trailer	1629	1737	1737
Bulk	- power unit	1954	2389	2171
	- trailer	1846	2497	2497

APPENDIX J/ CLEANING COSTS

Cleaning costs used by Trimac are shown in Table J.1. For this analysis, trucks (including pup trailers) are assumed to have these costs:

- Vans and reefers have the costs shown by Trimac under "dry freight" 2-axle diesel trucks.
- Tanks have the costs shown by Trimac for bulk trucks.
- All other trucks have a zero cleaning costs.

For tractor-trailer combinations, the following Trimac costs are assumed applicable:

- Tractors have the costs shown by Trimac for a train power unit.
- Single trailers have the costs shown by Trimac for 5-axle combinations, again the division between vans/reefers, tanks, and all others follows the same pattern as that outlined for trucks.
- Double trailers have the costs shown by Trimac for trains and, again, the van/reefer, tank, all other pattern is followed.

The result of these assumptions is shown on Table 6.4.

Table J.1/ Trimac Cleaning Costs

Cleaning Costs per Kilometre (cents)

		Ontario	Quebec	New Brunswick
2-axle diesel truck				
Dry Freight		0.4	0.4	0.4
Bulk		1.1	0.9	0.8
5-axle tractor-semitrailer				
Dry Freight	- power unit	0.4	0.4	0.2
	- trailer	1.9	1.8	0.6
Bulk	- power unit	0.4	0.4	0.2
	- trailer	2.1	2.1	0.5
7/8-axle train				
Dry Freight	- power unit	0.4	0.4	0.3
	- trailer	2.0	1.9	0.8
Bulk	- power unit	0.4	0.4	0.3
	- trailer	2.2	2.2	1.0

APPENDIX K/ OVERVIEW OF COSTING PROCEDURES AND COMPARISON WITH TRIMAC

The next few pages show a sample output from the cost model for vans in Ontario. This is Scenario #1, the "base case" of current liftable-axle loads (although, given the configuration shown, the specification of a regulatory scenario is irrelevant). Table K.1 shows the parameters specified at the start of the program and Table K.2 shows the outputs. Table K.3 then shows a comparison of these procedures with those of Trimac.

As shown on lines #4 and #5, of Table K.3, the costing procedures used here do not appear to produce costs anywhere close to those calculated by Trimac. Costs per kilometre are from 9 to 24% higher than Trimac's and costs per tonne are considerably lower (about half). However, and as shown in the balance of Table K.3, the differences can be accounted for. First, some of the higher per-tonne costs for the "dry freight" Trimac van are accounted for by the manner in which this general freight is loaded (see line #22); these costs are not relevant here as it is heavy, truckload freight that is at issue with trucks employing liftable axles. The Trimac "bulk" costs are more relevant for a comparison with the costs generated here.

Second, some of the productivity factors have been set at different levels than those used in Trimac's procedures. To show this, consider lines #6 and #7 where the productivity factors for these calculations are set as close to Trimac's as possible. An empty return trip is specified (line #6) and the annual hours are set at the same as those used in Trimac (2841). Trip distance (160 km), load/unload rates (for bulk commodities), and other productivity factors have already been set equal to Trimac's. Lines #8 to #10 show the calculated utilization rates. The high annual kilometres in the costing generated here is a function of the way trip time is calculated. That is, at 80 km/hr, there are four hours of driving plus load/unload time (32.7 t/hr). This trip time, divided into annual hours results in a certain number of annual trips which, when multiplied by the trip distance, produces the figures shown on Tables K.2 and K.3. The same is true of annual tonnes; that is, they are entirely a function of the calculated trip time, the resulting number of annual trips, and the already-determined payload.

Fixed and variable costs are calculated as discussed previously. The only point to note about the information shown on Table K.3 is that the Trimac labour rates include the driver's time spent while the truck is being loaded and unloaded. For the cost model developed here, these are treated as a separate category of costs (line #22) and Trimac's figures are re-stated just to show the comparison.

As shown on lines #27 to #29, when productivity factors are adjusted to coincide with Trimac's, the costs produced by these procedures are quite similar to those generated by Trimac – the somewhat lower figures being accounted for by the calculated higher annual distance and tonnes handled. When annual hours are re-adjusted back to their original 2000 hours (lines #30 to #32) – but an empty return trip still assumed – the costs calculated here are even closer to those calculated by Trimac: 9.4 to 10.8 cents per tonne-kilometre versus Trimac's 11.6 cents for bulk freight.

Table K.1/ Cost Model: Specified Parameters

1	Increase in maintenance and tire costs for axle loads over 8 t	20%
2	Increase in maintenance and tire costs for axle loads over 9 t	30%
3	Increase in maintenance and tire costs for spreads 1.8 - 2.0 m	10%
4	Increase in maintenance and tire costs for spreads over 2.0 m	20%
5	Trip length (km)	160
6	Annual operating hours	2000
7	Regulatory scenario (1 .. 4)	1
8	Backhaul (1), no backhaul (0)	1
9	Trip speed (km/hr)	80
10	Load/unload rate (tonnes/hr)	
11	loads under 23 tonnes	30.24
12	loads over 23 tonnes	32.70
13	Non-trip kilometres (% of total)	5%
14	Fuel consumption (km/L)	
15	fixed	3.4729
16	variable (with GVW)	0.0219
17	Overhead costs (% of truck operating)	23.29%
18	Cost of capital (pre tax)	20%

Table K.2/ Cost Model: Basic Outputs – Ontario, Van, Scenario #1

		Ontario 3-S2 van	
1	Configuration		
	Axle loads	Max.	High
	GVW (t)	45.2	42.0
	Payload (t)	31.4	26.1
2	Physical Outputs		
	Load/unload time (hr)	0.96	0.80
	Trip time (hr)	2.96	2.80
	Annual trips	676	715
	Annual tonnes	21 214	18 655
	Annual kilometres	113 504	120 079
3	Annual Fixed Costs		
	Depreciation	20 142	20 142
	Registration	1 915	1 734
	Other equipment	3 583	3 583
	Total	25 640	25 459
4	Variable Costs per Kilometre		
	Labour	0.251	0.251
	Fuel	0.190	0.185
	Maintenance	0.196	0.184
	Tres	0.064	0.061
	Heavy axles	0.078	0.049
	Cleaning	0.023	0.023
	Total	0.802	0.753
5	Annual Load/Unload Labour Costs	11 763	10 344
6	Annual Operating Costs (3+4+5)	128 416	126 182
7	Overheads	29 908	29 388
8	Return on Investment	26 612	26 612
9	Trucking Costs		
	per kilometre ($)	1.629	1.517
	per tonne ($)	8.717	9.766
	per tonne-kilometre ($)	0.0545	0.0610

Table K.3/ Comparison of Costs with Trimac

		Ontario 3-S2		Trimac 3-S2	
1	Freight	Max.	Heavy	Dry Fr.	Bulk
2	GVW (t)	45.2	42.0	47.2	47.2
3	Payload	31.4	26.1	22.57	22.68
	Costs				
4	cost per kilometre	1.629	1.517	1.388	1.316
5	cost per tonne	8.72	9.77	19.66	18.55
	Adjusting for Productivity				
6	backhaul	no		no	
7	annual hours	2,841		2,841	
	Physical Outputs				
8	trip running time (hrs)	4.96	4.80	5.70	5.70
9	annual kilometres	192 445	198 946	160 000	160 000
10	annual tonnes	17 984	15 454	11 285	11 340
	Fixed or Annual Costs				
11	depreciation	20 142	20 142	21 552	23 798
12	registration	1 915	1 734	2 006	2 006
13	other equipment	3 583	3 583	3 583	3 800
14	Total	25 640	25 459	27 141	29 604
	Variable Costs (per km)				
15	labour	0.251	0.251	0.388	0.289
16	fuel	0.167	0.166	0.196	0.205
17	maintenance	0.196	0.184	0.178	0.198
18	tires	0.064	0.061	0.058	0.058
19	heavy axles	0.039	0.024	--	--
20	cleaning	0.023	0.023	0.023	0.025
21	Total	0.740	0.710	0.843	0.775
	Other Annual Costs				
22	L/U costs	9 972	8 569	17 680	4 799
23	overhead	41 451	40 803	37 726	35 772
24	return on investment	26 612	26 612	22 192	21 042
25	Total	68 063	67 415	59 918	56 814
26	Total Costs (annual)	246 040	242 611	221 919	210 423
	Costs per Unit of Output				
27	per kilometre	1.278	1.219	1.388	1.316
28	per tonne	13.68	15.70	19.66	18.55
29	per tonne-kilometre	0.086	0.098	0.123	0.116
	Adjusting Annual Hours to 2000				
30	cost per kilometre	1.406	1.342		
31	cost per tonne	15.04	17.28		
32	cost per tonne-kilometre	0.094	0.108		

APPENDIX L/ TRUCKING COSTS

The 14 tables included in this Appendix contain trucking costs for all 24 configurations, all seven body types, in all three regions, under four regulatory scenarios, and with "max/high" payload assumptions. The fifth regulatory scenario does not result in any additional trucking costs. In addition, the parameters of the cost model have been set at the values discussed in Sections 4 to 7. Backhauls have been assumed for the first three body styles (van, refrigerated, flatdeck), and have not been assumed for the last four (tank, dump, hopper, log). The costing programs produce costs for the full range of truck types, even though some of these may not actually exist. For example, there is probably no such thing as a T4,1L hopper, as, as far as is known, it is not possible to fit a hopper mechanism into a straight truck configuration. These "unimportant" cells in the cost matrix are included here simply for completeness; they have no other meaning.

Table L.1/ Van Costs – 160 km haul, with backhaul, cents/tne-km

Configurations		Ontario	Quebec	Atlantic
1	T3	6.98 - 8.08	6.97 - 8.12	6.79 - 7.62
2	T4, 1L	5.24 - 5.67		
3	T4	5.46 - 6.06	5.54 - 6.10	
4	T3-2	5.17 - 5.80	5.12 - 5.69	4.90 - 5.22
5	T3-3	4.57 - 4.81	4.56 - 4.88	4.22 - 4.41
6	T3-4	4.22 - 4.33	4.64 - 4.59	4.05 - 4.15
7	T4-4, 1L	4.24 - 4.30		
8	3-S2	5.45 - 6.10	5.43 - 6.23	5.01 - 5.70
9	3-S3	4.70 - 5.48	4.64 - 5.49	4.27 - 4.89
10	3-S3, 1L	4.66 - 5.04	4.64 - 5.14	4.24 - 4.64
11	3-S4	4.45 - 4.66	4.78 - 5.04	
12	3-S4, 1L	4.45 - 4.77	5.00 - 5.00	
13	3-S4, 2L	4.41 - 4.62		
14	3-S5, 1L	4.39 - 4.47		
15	3-S5, 2L	4.39 - 4.43		
16	3-S6, 1L	4.35 - 4.63		
17	3-S6, 2L	4.35 - 4.64		
18	3-S3-S2	4.85 - 4.95	5.08 - 5.25	4.56 - 4.81
19	3-S3-S2, 1L	4.85 - 4.95	5.08 - 5.25	
20	3-S2-3	4.92 - 5.03	5.31 - 5.54	5.35 - 5.74
21	RTAC 3-S3	5.29 - 5.59	5.41 - 5.72	4.54 - 4.90
22	RTAC 3-S2-S2	5.16 - 5.49	5.25 - 5.60	4.55 - 4.84
23	RTAC 3-S3-S2	4.81 - 4.85	4.89 - 4.94	4.25 - 4.29
24	RTAC 3-S2=3	5.00 - 5.26	5.08 - 5.35	4.42 - 4.65

Table L.2/ Van Costs: Regulatory Secenatio #2 – #4
160 km haul, with backhaul, cents/tne-km

Configurations		Ontario	Quebec	Atlantic
SCENARIO #2				
2	T4, 1L	5.42 - 6.15		
7	T4-4, 1L	4.24 - 4.30		
10	3-S3, 1L	4.78 - 5.17	4.80 - 5.28	4.33 - 4.75
12	3-S4, 1L	4.45 - 4.96	5.00 - 4.95	
13	3-S4, 2L	4.45 - 4.70		
14	3-S5, 1L	4.39 - 4.47		
15	3-S5, 2L	4.39 - 4.43		
16	3-S6, 1L	4.35 - 4.63		
17	3-S6, 2L	4.35 - 4.64		
19	3-S3-S2, 1L	4.85 - 4.95	5.08 - 5.25	
SCENARIO #3				
2	T4, 1L	5.78 - 6.63		
7	T4-4, 1L	4.24 - 4.30		
10	3-S3, 1L	4.97 - 5.42	4.99 - 5.54	4.52 - 4.80
12	3-S4, 1L	4.52 - 4.95	5.00 - 5.17	
13	3-S4, 2L	4.65 - 4.87		
14	3-S5, 1L	4.39 - 4.47		
15	3-S5, 2L	4.39 - 4.60		
16	3-S6, 1L	4.35 - 4.63		
17	3-S6, 2L	4.35 - 4.64		
19	3-S3-S2, 1L	4.85 - 4.95	5.08 - 5.25	
SCENARIO #4				
2	T4, 1L	7.07 - 8.45		
7	T4-4, 1L	4.28 - 4.25		
10	3-S3, 1L	5.36 - 6.15	5.57 - 6.31	5.06 - 5.76
12	3-S4, 1L	4.92 - 5.70	5.00 - 6.00	
13	3-S4, 2L	5.76 - 6.66		
14	3-S5, 1L	4.33 - 4.57		
15	3-S5, 2L	4.89 - 6.00		
16	3-S6, 1L	4.35 - 4.63		
17	3-S6, 2L	4.47 - 4.76		
19	3-S3-S2, 1L	4.76 - 5.08	5.08 - 5.25	

Table L.3/ Reefer Costs – 160 km haul, with backhaul, cents/tne-km

Configurations		Ontario	Quebec	Atlantic
1	T3	8.24 - 10.06	8.18 - 10.11	8.18 - 9.68
2	T4, 1L	5.96 - 6.70		
3	T4	6.21 - 7.18	6.29 - 7.22	
4	T3-2	6.49 - 8.17	6.42 - 7.89	6.39 - 7.61
5	T3-3	5.63 - 6.32	5.62 - 6.45	5.37 - 6.02
6	T3-4	5.12 - 5.51	5.73 - 5.98	5.12 - 5.53
7	T4-4, 1L	5.15 - 5.46		
8	3-S2	6.30 - 7.56	6.27 - 7.76	5.98 - 7.29
9	3-S3	5.32 - 6.63	5.30 - 6.65	5.03 - 6.03
10	3-S3, 1L	5.33 - 5.96	5.30 - 6.12	4.99 - 5.67
11	3-S4	5.06 - 5.45	5.51 - 6.08	
12	3-S4, 1L	5.06 - 5.63	5.77 - 5.96	
13	3-S4, 2L	5.02 - 5.40		
14	3-S5, 1L	4.98 - 5.21		
15	3-S5, 2L	4.98 - 5.17		
16	3-S6, 1L	4.95 - 5.41		
17	3-S6, 2L	4.94 - 5.43		
18	3-S3-S2	5.93 - 6.61	6.32 - 7.14	5.84 - 6.78
19	3-S3-S2, 1L	5.92 - 6.60	6.32 - 7.14	
20	3-S2-3	5.97 - 6.69	6.59 - 7.59	6.99 - 8.69
21	RTAC 3-S3	6.19 - 6.85	6.36 - 7.05	5.39 - 6.12
22	RTAC 3-S2-S2	6.36 - 7.47	6.51 - 7.65	5.75 - 6.74
23	RTAC 3-S3-S2	5.90 - 6.46	6.02 - 6.61	5.34 - 5.84
24	RTAC 3-S2=3	6.17 - 7.09	6.31 - 7.25	5.59 - 6.41

Table L.4/ Reefer Costs: Regulatory Scenario #2 – #4
160 km haul, with backhaul, cents/tne-km

Configurations		Ontario	Quebec	Atlantic
SCENARIO #2				
2	T4, 1L	6.19 - 7.25		
7	T4-4, 1L	5.15 - 5.46		
10	3-S3, 1L	5.48 - 6.17	5.51 - 6.33	5.10 - 5.83
12	3-S4, 1L	5.06 - 5.88	5.77 - 5.94	
13	3-S4, 2L	5.06 - 5.53		
14	3-S5, 1L	4.98 - 5.21		
15	3-S5, 2L	4.98 - 5.17		
16	3-S6, 1L	4.95 - 5.41		
17	3-S6, 2L	4.94 - 5.43		
19	3-S3-S2, 1L	5.92 - 6.60	6.32 - 7.14	
SCENARIO #3				
2	T4, 1L	6.72 - 7.91		
7	T4-4, 1L	5.15 - 5.46		
10	3-S3, 1L	5.73 - 6.53	5.75 - 6.70	5.36 - 5.97
12	3-S4, 1L	5.14 - 5.93	5.77 - 6.25	
13	3-S4, 2L	5.34 - 5.81		
14	3-S5, 1L	4.98 - 5.21		
15	3-S5, 2L	4.98 - 5.40		
16	3-S6, 1L	4.95 - 5.41		
17	3-S6, 2L	4.94 - 5.43		
19	3-S3-S2, 1L	5.92 - 6.60	6.32 - 7.14	
SCENARIO #4				
2	T4, 1L	8.40 - 10.71		
7	T4-4, 1L	5.20 - 5.45		
10	3-S3, 1L	6.31 - 7.80	6.53 - 8.03	6.16 - 7.56
12	3-S4, 1L	5.68 - 7.03	5.77 - 7.50	
13	3-S4, 2L	6.86 - 8.63		
14	3-S5, 1L	4.93 - 5.35		
15	3-S5, 2L	5.66 - 7.42		
16	3-S6, 1L	4.95 - 5.41		
17	3-S6, 2L	5.10 - 5.59		
19	3-S3-S2, 1L	5.86 - 6.83	6.32 - 7.14	

Table L.5/ Flatdeck Costs – 160 km haul, with backhaul, cents/tne-km

Configurations		Ontario	Quebec	Atlantic
1	T3	7.02 - 8.04	7.03 - 8.11	6.81 - 7.57
2	T4, 1L	5.28 - 5.69		
3	T4	5.50 - 6.08	5.60 - 6.13	
4	T3-2	5.01 - 5.64	4.97 - 5.55	4.77 - 5.12
5	T3-3	4.45 - 4.70	4.45 - 4.77	4.14 - 4.34
6	T3-4	4.11 - 4.22	4.52 - 4.49	3.97 - 4.09
7	T4-4, 1L	4.13 - 4.19		
8	3-S2	5.33 - 5.90	5.33 - 6.04	4.93 - 5.54
9	3-S3	4.62 - 5.35	4.56 - 5.37	4.22 - 4.81
10	3-S3, 1L	4.57 - 4.92	4.55 - 5.03	4.19 - 4.56
11	3-S4	4.38 - 4.58	4.72 - 4.96	
12	3-S4, 1L	4.38 - 4.69	4.94 - 4.92	
13	3-S4, 2L	4.34 - 4.53		
14	3-S5, 1L	4.31 - 4.37		
15	3-S5, 2L	4.31 - 4.34		
16	3-S6, 1L	4.27 - 4.52		
17	3-S6, 2L	4.27 - 4.54		
18	3-S3-S2	4.70 - 4.83	4.92 - 5.12	4.43 - 4.71
19	3-S3-S2, 1L	4.70 - 4.82	4.92 - 5.12	
20	3-S2-3	4.76 - 4.89	5.13 - 5.40	5.19 - 5.62
21	RTAC 3-S3	5.19 - 5.44	5.32 - 5.59	4.49 - 4.81
22	RTAC 3-S2-S2	4.99 - 5.36	5.09 - 5.47	4.42 - 4.74
23	RTAC 3-S3-S2	4.66 - 4.73	4.74 - 4.81	4.13 - 4.19
24	RTAC 3-S2=3	4.83 - 5.13	4.92 - 5.23	4.29 - 4.55

Table L.6/ Flatdeck Costs: Regulatory Scenario #2 – #4
160 km haul, with backhaul, cents/tne-km

Configurations		Ontario	Quebec	Atlantic
SCENARIO #2				
2	T4, 1L	5.47 - 6.09		
7	T4-4, 1L	4.13 - 4.19		
10	3-S3, 1L	4.69 - 5.04	4.72 - 5.16	4.18 - 4.67
12	3-S4, 1L	4.38 - 4.87	4.94 - 4.87	
13	3-S4, 2L	4.38 - 4.61		
14	3-S5, 1L	4.31 - 4.37		
15	3-S5, 2L	4.31 - 4.34		
16	3-S6, 1L	4.27 - 4.52		
17	3-S6, 2L	4.27 - 4.54		
19	3-S3-S2, 1L	4.70 - 4.82	4.92 - 5.12	
SCENARIO #3				
2	T4, 1L	5.82 - 6.64		
7	T4-4, 1L	4.13 - 4.19		
10	3-S3, 1L	4.88 - 5.29	4.91 - 5.42	4.47 - 4.72
12	3-S4, 1L	4.45 - 4.86	4.94 - 5.08	
13	3-S4, 2L	4.59 - 4.78		
14	3-S5, 1L	4.31 - 4.37		
15	3-S5, 2L	4.31 - 4.51		
16	3-S6, 1L	4.27 - 4.52		
17	3-S6, 2L	4.27 - 4.54		
19	3-S3-S2, 1L	4.70 - 4.82	4.92 - 5.12	
SCENARIO #4				
2	T4, 1L	7.10 - 8.39		
7	T4-4, 1L	4.16 - 4.14		
10	3-S3, 1L	5.26 - 5.99	5.49 - 6.16	5.00 - 5.65
12	3-S4, 1L	4.86 - 5.61	4.94 - 5.92	
13	3-S4, 2L	5.70 - 6.55		
14	3-S5, 1L	4.25 - 4.48		
15	3-S5, 2L	4.82 - 5.89		
16	3-S6, 1L	4.27 - 4.52		
17	3-S6, 2L	4.39 - 4.65		
19	3-S3-S2, 1L	4.61 - 4.95	4.92 - 5.12	

Table L.7/ Tank Costs – 160 km haul, no backhaul, cents/tne-km

Configurations		Ontario	Quebec	Atlantic
1	T3	13.47 - 16.44	14.57 - 18.01	14.05 - 16.81
2	T4, 1L	9.79 - 10.96		
3	T4	10.21 - 11.85	11.18 - 12.90	
4	T3-2	10.33 - 12.19	10.87 - 12.72	10.47 - 11.78
5	T3-3	9.10 - 9.83	9.60 - 10.59	8.96 - 9.70
6	T3-4	8.24 - 8.61	9.85 - 9.91	8.59 - 8.97
7	T4-4, 1L	8.33 - 8.57		
8	3-S2	10.22 - 11.53	10.17 - 11.79	9.66 - 10.90
9	3-S3	9.20 - 11.05	9.02 - 11.06	8.66 - 10.01
10	3-S3, 1L	9.10 - 8.63	9.00 - 10.12	8.57 - 9.42
11	3-S4	8.63 - 9.07	9.48 - 10.32	
12	3-S4, 1L	8.61 - 9.43	9.97 - 9.94	
13	3-S4, 2L	8.53 - 8.96		
14	3-S5, 1L	8.53 - 8.89		
15	3-S5, 2L	8.52 - 8.80		
16	3-S6, 1L	8.62 - 9.22		
17	3-S6, 2L	8.61 - 9.26		
18	3-S3-S2	9.73 - 10.28	10.53 - 10.97	9.69 - 10.31
19	3-S3-S2, 1L	9.72 - 10.27	10.52 - 10.96	
20	3-S2-3	9.68 - 10.35	10.87 - 11.57	11.40 - 12.52
21	RTAC 3-S3	10.74 - 11.57	11.00 - 11.86	9.31 - 10.30
22	RTAC 3-S2-S2	10.32 - 11.22	10.51 - 11.44	9.21 - 10.00
23	RTAC 3-S3-S2	9.66 - 10.03	9.82 - 10.21	8.67 - 9.02
24	RTAC 3-S2=3	10.13 - 10.89	10.32 - 11.10	9.07 - 9.75

Table L.8/ Tank Costs: Regulatory Scenario #2 – #4
160 km haul, no backhaul, cents/tne-km

Configurations		Ontario	Quebec	Atlantic
SCENARIO #2				
2	T4, 1L	10.18 - 11.95		
7	T4-4, 1L	8.33 - 8.57		
10	3-S3, 1L	9.37 - 10.31	9.39 - 10.55	8.78 - 9.69
12	3-S4, 1L	8.61 - 9.86	9.97 - 10.53	
13	3-S4, 2L	8.61 - 9.25		
14	3-S5, 1L	8.53 - 8.89		
15	3-S5, 2L	8.52 - 8.80		
16	3-S6, 1L	8.62 - 9.22		
17	3-S6, 2L	8.61 - 9.26		
19	3-S3-S2, 1L	9.72 - 10.27	10.52 - 10.96	
SCENARIO #3				
2	T4, 1L	10.93 - 13.05		
7	T4-4, 1L	8.33 - 8.57		
10	3-S3, 1L	9.81 - 10.89	9.82 - 11.15	9.25 - 10.06
12	3-S4, 1L	8.77 - 10.11	9.97 - 10.60	
13	3-S4, 2L	9.20 - 9.90		
14	3-S5, 1L	8.53 - 8.89		
15	3-S5, 2L	8.52 - 9.21		
16	3-S6, 1L	8.62 - 9.22		
17	3-S6, 2L	8.61 - 9.26		
19	3-S3-S2, 1L	9.72 - 10.27	10.52 - 10.96	
SCENARIO #4				
2	T4, 1L	13.99 - 17.75		
7	T4-4, 1L	8.42 - 8.67		
10	3-S3, 1L	11.14 - 12.91	11.31 - 13.25	10.83 - 12.48
12	3-S4, 1L	9.85 - 11.90	9.97 - 12.60	
13	3-S4, 2L	12.17 - 14.20		
14	3-S5, 1L	9.61 - 9.14		
15	3-S5, 2L	9.98 - 12.55		
16	3-S6, 1L	8.62 - 9.22		
17	3-S6, 2L	8.90 - 9.54		
19	3-S3-S2, 1L	9.80 - 10.58	10.52 - 10.96	

Table L.9/ Dump Costs – 160 km haul, no backhaul, cents/tne-km

Configurations		Ontario	Quebec	Atlantic
1	T3	12.30 - 15.11	12.42 - 15.33	11.60 - 13.97
2	T4, 1L	8.99 - 10.07		
3	T4	9.40 - 10.91	9.66 - 11.07	
4	T3-2	9.26 - 10.77	9.25 - 10.63	8.75 - 9.71
5	T3-3	7.97 - 9.03	8.05 - 9.26	7.34 - 8.35
6	T3-4	7.23 - 7.83	8.26 - 8.61	7.04 - 7.68
7	T4-4, 1L	7.31 - 7.79		
8	3-S2	10.15 - 11.48	10.12 - 11.77	9.63 - 10.92
9	3-S3	8.64 - 10.28	8.50 - 10.32	8.11 - 9.33
10	3-S3, 1L	8.53 - 9.26	8.48 - 9.48	8.02 - 8.80
11	3-S4	8.00 - 8.55	8.79 - 9.71	
12	3-S4, 1L	7.99 - 8.88	9.24 - 9.38	
13	3-S4, 2L	7.90 - 8.44		
14	3-S5, 1L	7.91 - 8.34		
15	3-S5, 2L	7.90 - 8.25		
16	3-S6, 1L	7.98 - 8.65		
17	3-S6, 2L	7.97 - 8.70		
18	3-S3-S2	9.24 - 10.07	10.01 - 10.79	9.13 - 10.10
19	3-S3-S2, 1L	9.23 - 10.05	10.00 - 10.79	
20	3-S2-3	9.42 - 9.83	10.58 - 10.99	11.07 - 11.80
21	RTAC 3-S3	10.00 - 10.72	10.27 - 11.02	8.68 - 9.56
22	RTAC 3-S2-S2	10.02 - 10.65	10.22 - 10.87	8.92 - 9.48
23	RTAC 3-S3-S2	9.15 - 9.80	9.32 - 10.00	8.16 - 8.75
24	RTAC 3-S2=3	9.83 - 10.33	10.02 - 10.54	8.78 - 9.23

Table L.10/ Dump Costs: Regulatory Scenario #2 - #4 –
160 km haul, no backhaul, cents/tne-km

Configurations		Ontario	Quebec	Atlantic
SCENARIO #2				
2	T4, 1L	9.35 - 10.97		
7	T4-4, 1L	7.31 - 7.79		
10	3-S3, 1L	8.78 - 9.62	8.84 - 9.86	8.21 - 9.04
12	3-S4, 1L	7.99 - 9.28	9.24 - 9.49	
13	3-S4, 2L	7.97 - 8.71		
14	3-S5, 1L	7.91 - 8.34		
15	3-S5, 2L	7.90 - 8.25		
16	3-S6, 1L	7.98 - 8.65		
17	3-S6, 2L	7.97 - 8.70		
19	3-S3-S2, 1L	9.23 - 10.05	10.00 - 10.79	
SCENARIO #3				
2	T4, 1L	10.03 - 11.97		
7	T4-4, 1L	7.31 - 7.79		
10	3-S3, 1L	9.19 - 10.14	9.24 - 10.41	8.63 - 9.35
12	3-S4, 1L	8.13 - 9.49	9.24 - 9.98	
13	3-S4, 2L	8.50 - 9.30		
14	3-S5, 1L	7.91 - 8.34		
15	3-S5, 2L	7.90 - 8.63		
16	3-S6, 1L	7.98 - 8.65		
17	3-S6, 2L	7.97 - 8.70		
19	3-S3-S2, 1L	9.23 - 10.05	10.00 - 10.79	
SCENARIO #4				
2	T4, 1L	12.74 - 16.15		
7	T4-4, 1L	7.38 - 7.86		
10	3-S3, 1L	10.36 - 11.94	10.60 - 12.29	10.05 - 11.44
12	3-S4, 1L	9.09 - 11.18	9.24 - 11.86	
13	3-S4, 2L	11.12 - 13.33		
14	3-S5, 1L	7.37 - 8.58		
15	3-S5, 2L	9.20 - 11.76		
16	3-S6, 1L	7.98 - 8.65		
17	3-S6, 2L	8.24 - 8.96		
19	3-S3-S2, 1L	9.28 - 10.38	10.00 - 10.79	

Table L.11/ Hopper Costs – 160 km haul, no backhaul, cents/tne-km

Configurations		Ontario	Quebec	Atlantic
1	T3	12.55 - 15.11	12.67 - 15.33	11.86 - 13.97
2	T4, 1L	9.12 - 10.07		
3	T4	9.53 - 10.91	9.79 - 11.07	
4	T3-2	9.14 - 10.51	9.13 - 10.37	8.62 - 9.44
5	T3-3	7.92 - 8.88	7.99 - 9.11	7.27 - 8.20
6	T3-4	7.17 - 7.70	8.20 - 8.47	6.97 - 7.54
7	T4-4, 1L	7.25 - 7.67		
8	3-S2	9.63 - 11.24	9.62 - 11.53	9.07 - 10.66
9	3-S3	8.37 - 9.96	8.24 - 10.00	7.81 - 9.00
10	3-S3, 1L	8.27 - 8.97	8.23 - 9.20	7.73 - 8.48
11	3-S4	8.09 - 8.55	8.94 - 9.75	
12	3-S4, 1L	8.08 - 8.89	9.42 - 9.40	
13	3-S4, 2L	7.99 - 8.43		
14	3-S5, 1L	8.00 - 8.33		
15	3-S5, 2L	7.98 - 8.24		
16	3-S6, 1L	8.08 - 8.65		
17	3-S6, 2L	8.06 - 8.70		
18	3-S3-S2	8.94 - 9.73	9.69 - 10.44	8.78 - 9.72
19	3-S3-S2, 1L	8.93 - 9.72	9.68 - 10.43	
20	3-S2-3	9.06 - 9.44	10.17 - 10.57	10.57 - 11.27
21	RTAC 3-S3	9.68 - 10.38	9.95 - 10.68	8.37 - 9.21
22	RTAC 3-S2-S2	9.62 - 10.23	9.82 - 10.45	8.51 - 9.05
23	RTAC 3-S3-S2	8.85 - 9.47	9.02 - 9.67	7.85 - 8.41
24	RTAC 3-S2=3	9.43 - 9.92	9.63 - 10.13	8.38 - 8.81

Table L.12/ Hopper Costs: Regulatory Scenario #2 - #4 –
160 km haul, no backhaul, cents/tne-km

Configurations		Ontario	Quebec	Atlantic
SCENARIO #2				
2	T4, 1L	9.49 - 10.97		
7	T4-4, 1L	7.25 - 7.67		
10	3-S3, 1L	8.51 - 9.32	8.58 - 9.56	7.91 - 8.71
12	3-S4, 1L	8.08 - 9.31	9.42 - 9.52	
13	3-S4, 2L	8.06 - 8.71		
14	3-S5, 1L	8.00 - 8.33		
15	3-S5, 2L	7.98 - 8.24		
16	3-S6, 1L	8.08 - 8.65		
17	3-S6, 2L	8.06 - 8.70		
19	3-S3-S2, 1L	8.93 - 9.72	9.68 - 10.43	
SCENARIO #3				
2	T4, 1L	10.19 - 11.97		
7	T4-4, 1L	7.25 - 7.67		
10	3-S3, 1L	8.91 - 9.83	8.96 - 10.09	8.32 - 9.00
12	3-S4, 1L	8.23 - 9.53	9.42 - 10.03	
13	3-S4, 2L	8.63 - 9.32		
14	3-S5, 1L	8.00 - 8.33		
15	3-S5, 2L	7.98 - 8.63		
16	3-S6, 1L	8.08 - 8.65		
17	3-S6, 2L	8.06 - 8.70		
19	3-S3-S2, 1L	8.93 - 9.72	9.68 - 10.43	
SCENARIO #4				
2	T4, 1L	13.01 - 16.15		
7	T4-4, 1L	7.32 - 7.73		
10	3-S3, 1L	10.03 - 11.56	10.28 - 11.91	9.68 - 11.03
12	3-S4, 1L	9.27 - 11.30	9.42 - 12.02	
13	3-S4, 2L	11.50 - 13.69		
14	3-S5, 1L	8.06 - 8.58		
15	3-S5, 2L	9.38 - 11.91		
16	3-S6, 1L	8.08 - 8.65		
17	3-S6, 2L	8.35 - 8.97		
19	3-S3-S2, 1L	8.98 - 10.03	9.68 - 10.43	

Table L.13: Log Costs – 160 km haul, no backhaul, cents/tne-km

Configurations		Ontario	Quebec	Atlantic
1	T3	12.24 - 14.64	12.36 - 14.85	11.54 - 13.51
2	T4, 1L	8.96 - 9.92		
3	T4	9.37 - 10.66	9.63 - 10.83	
4	T3-2	8.90 - 10.13	8.91 - 10.01	8.37 - 9.08
5	T3-3	7.74 - 8.24	7.82 - 8.45	7.09 - 7.56
6	T3-4	7.02 - 7.23	8.03 - 7.90	6.80 - 7.01
7	T4-4, 1L	7.10 - 7.20		
8	3-S2	9.72 - 10.88	9.71 - 11.16	9.16 - 10.28
9	3-S3	8.25 - 9.75	8.13 - 9.80	7.68 - 8.79
10	3-S3, 1L	8.15 - 8.79	8.11 - 9.02	7.59 - 8.29
11	3-S4	7.72 - 8.05	8.50 - 9.09	
12	3-S4, 1L	7.70 - 8.34	8.95 - 8.80	
13	3-S4, 2L	7.61 - 7.94		
14	3-S5, 1L	7.63 - 7.86		
15	3-S5, 2L	7.62 - 7.77		
16	3-S6, 1L	7.69 - 8.15		
17	3-S6, 2L	7.67 - 8.20		
18	3-S3-S2	8.78 - 9.06	9.51 - 9.67	8.59 - 8.95
19	3-S3-S2, 1L	8.77 - 9.05	9.50 - 9.67	
20	3-S2-3	8.87 - 9.15	9.94 - 10.22	10.28 - 10.81
21	RTAC 3-S3	9.54 - 10.15	9.80 - 10.45	8.22 - 8.99
22	RTAC 3-S2-S2	9.41 - 9.89	9.60 - 10.10	8.31 - 8.73
23	RTAC 3-S3-S2	8.68 - 8.82	8.85 - 9.00	7.68 - 7.81
24	RTAC 3-S2=3	9.25 - 9.60	9.44 - 9.80	8.20 - 8.51

TABLE L.14/ Log Costs: Regulatory Scenario #2 - #4
160 km haul, no backhaul, cents/tne-km

Configurations		Ontario	Quebec	Atlantic
SCENARIO #2				
2	T4, 1L	9.32 - 10.78		
7	T4-4, 1L	7.10 - 7.20		
10	3-S3, 1L	8.38 - 9.13	8.46 - 9.37	7.78 - 8.51
12	3-S4, 1L	7.70 - 8.71	8.95 - 8.89	
13	3-S4, 2L	7.69 - 8.18		
14	3-S5, 1L	7.63 - 7.86		
15	3-S5, 2L	7.62 - 7.77		
16	3-S6, 1L	7.69 - 8.15		
17	3-S6, 2L	7.67 - 8.20		
19	3-S3-S2, 1L	8.77 - 9.05	9.50 - 9.67	
SCENARIO #3				
2	T4, 1L	10.00 - 11.75		
7	T4-4, 1L	7.10 - 7.20		
10	3-S3, 1L	8.78 - 9.63	8.84 - 9.89	8.18 - 8.79
12	3-S4, 1L	7.85 - 8.89	8.95 - 9.34	
13	3-S4, 2L	8.20 - 8.71		
14	3-S5, 1L	7.63 - 7.86		
15	3-S5, 2L	7.62 - 8.12		
16	3-S6, 1L	7.69 - 8.15		
17	3-S6, 2L	7.67 - 8.20		
19	3-S3-S2, 1L	8.77 - 9.05	9.50 - 9.67	
SCENARIO #4				
2	T4, 1L	12.68 - 15.71		
7	T4-4, 1L	7.17 - 7.24		
10	3-S3, 1L	9.88 - 11.30	10.14 - 11.65	9.51 - 10.75
12	3-S4, 1L	8.79 - 10.43	8.95 - 11.06	
13	3-S4, 2L	10.78 - 12.38		
14	3-S5, 1L	7.68 - 8.08		
15	3-S5, 2L	8.89 - 11.01		
16	3-S6, 1L	7.69 - 8.15		
17	3-S6, 2L	7.93 - 8.44		
19	3-S3-S2, 1L	8.81 - 9.32	9.50 - 9.67	

APPENDIX M/ DEVELOPMENT OF MACRO ESTIMATES

This appendix contains details on the construction of Table 12.1, and a description of a sensitivity analysis. The details of Table 12.1 are shown on Tables M.1 to M.3, and the steps in this process are (following the columns in the three tables):

- **Column 1** – A frequency distribution of freight, as measured by tonnes, for each configuration is created from information described in Section 11. The exception to this is in the case of Quebec where the full survey results (2681) could not be used. The data for Quebec in Table M.2 is from a sub-sample of the survey (402 trucks) where the information on weight was more accurate. This results in some discrepancies with the information shown in Section 11, the most important of which is the measure of total tonnes moving on trucks with liftable axles – 32.4% in Section 11 versus 45.1% here.

- **Column 2** – A cost-per-tonne index is developed from the information described in Section 9 (or Appendix L). For each configuration, costs per tonnes were calculated for each body style, at the base parameters of the cost model (2000 hours, 160 km trip distance, etc.). The costs of the individual body styles were then weighted as follows:

van	0.67
refrigerated	0.14
flatdeck	0.11
tank	0.03
dump	0.03
hopper	0.01
log	0.01
	====
	1.00

For "other" configurations, that is, configurations not specifically identified in the 24 defined here, the costs of the 3-S2 are used.

- **Column 3** – Statistics Canada's estimate of total 1987 domestic tonnes originating in each region (Table 11.1) are then distributed among the configurations according to the road-side survey data (column #1).

- **Column 4** – Total annual tonnes are multiplied by the cost-per-tonne index for the purpose of creating a new index.

- **Column 5** – The new index (annual tonnes times the cost-per-tonne index) represents the distribution of total annual trucking expenses within a region among truck configurations.

- **Column 6** – Statistics Canada's 1987 measure of total operating expenses for for-hire and private trucking are multiplied by the new index to create a distribution of trucking expenses in each region by truck configuration.

These procedures make use of two weak assumptions: (i) that carriers domiciled within a region haul all freight originating in a region; and (ii) that total truck operating expenses are solely related to the business of hauling domestic freight (as compared to warehousing, packaging, insurance, and various other trucking-related services). Both assumptions are open to criticism; however, in the absence of any other information and as they are as valid as any other assumptions, they have been employed here.

To test these and other assumptions, the results were subjected to a sensitivity analysis, shown in Table M.4. The first part of this analysis (lines 2, 3, and 4 on Table M.4) alters the assumption concerning the split between "rough" and "other" freight. As shown, the results displayed in Table 12.1 are quite sensitive to this assumption, but even in the case where "rough" freight is entirely eliminated – that is, where no freight shifts to a truck-plus-trailer and, as a consequence, where no hauling costs actually drop – the largest impact of the policy options still only amounts to a relatively small 2.61% of total trucking costs. The next part of the analysis (line 5) reduces the total trucking operating expenses to those which approximate the revenues earned on domestic freight shipments. That is, rather than use Statistics Canada's measure of total operating expenses in each region for 1987, these have been reduced to that portion of total revenues earned on domestic freight movements in each region (79.1% in Ontario, 85.4% in Quebec, and 89.9% in Atlantic Canada). The impact of this change is small. The third part of the analysis (line 6) changes the tonnes affected from Statistic Canada's estimate of total originating to total tonnes destined to each region. Again, the impact is small (in fact, so small that it does not show up in the amounts shown on Table M.4). The final part of the analysis (line 7) uses the distribution of freight shown in Section 11 for each configuration (with some crude estimates where data were insufficient). As shown, this has a small but noticeable impact (downward) on the estimates contained in Table 12.1.

Table M.1/ Ontario: Elements for Macro Estimate

Vehicle Configuration	1 Dist. of Tonnes	2 Cost Index	3 Total Annual Tonnes	4 Tonnes X Cost Index	5 Dist. of Op. Expenses	6 Total Annual Op. Expenses
	%				%	million $
T3	1.05	1.000	1116141	1116141	1.51	83.9
T4,1L	0.16	0.694	170079	118035	0.16	8.9
T4	0.38	0.743	403938	300126	0.41	22.6
T3-2	0.07	0.729	74410	54245	0.07	4.1
T3-3	0.21	0.598	223229	133491	0.18	10.0
T3-4	0.26	0.535	276378	147862	0.20	11.1
T4-4,lL	0.15	0.531	159449	84667	0.11	6.4
3-S2	49.30	0.751	52405611	39356614	53.29	2959.9
3-S3	7.42	0.674	7887417	5316119	7.20	399.8
3-S3,1L	13.21	0.617	14042153	8664008	11.73	651.6
3-S4	3.36	0.570	3571660	2035846	2.76	153.1
3-S4,1L	2.01	0.585	2136618	1249922	1.69	94.0
3-S4,2L	3.80	0.565	4039378	2282248	3.09	171.6
3-S5,1L	1.15	0.547	1222443	668676	0.91	50.3
3-S5,2L	1.48	0.542	1573231	852691	1.15	64.1
3-S6,1L	0.22	0.566	233859	132364	0.18	10.0
3-S6,2L	0.32	0.569	340158	193550	0.26	14.6
3-S3-S2	6.43	0.621	6835052	4244567	5.75	319.2
3-S3-S2,1L	1.67	0.620	1775200	1100624	1.49	82.8
3-S2-3	0.59	0.629	627167	394488	0.53	29.7
Other	6.76	0.751	7185840	5403752	7.32	406.4
Total	100.00		106299414		100.00	5554.1

Table M.2/ Quebec: Elements for Macro Estimate

Vehicle Configuration	1 Dist. of Tonnes	2 Cost Index	3 Total Annual Tonnes	4 Tonnes X Cost Index	5 Dist. of Op. Expenses	6 Total Annual Op. Expenses
	%				%	million $
T3	3.20	1.000	1784932	1784932	4.59	116.0
T4	1.09	0.744	607992	452346	1.16	29.4
T3-2	0.30	0.709	167337	118642	0.31	7.7
T3-3	0.33	0.604	184071	111179	0.29	7.2
T3-4	0.36	0.567	200805	113856	0.29	7.4
3-S2	27.31	0.761	15233279	11592525	29.84	753.2
3-S3	2.21	0.670	1232719	825921	2.13	53.7
3-S3,1L	28.84	0.625	16086699	10054187	25.88	653.2
3-S4,1L	13.93	0.609	7770032	4731949	12.18	307.5
3-S3-S2	4.60	0.655	2565840	1680625	4.33	109.2
3-S3-S2,1L	2.33	0.655	1299654	851273	2.19	55.3
3-S2-3	1.05	0.690	585681	404120	1.04	26.3
Other	14.45	0.761	8060083	6133723	15.79	398.6
Total	100.00		55779124		100.00	2524.6

Table M.3/ Atlantic Canada: Elements for Macro Estimate

Vehicle Configuration	1 Dist. of Tonnes	2 Cost Index	3 Total Annual Tonnes	4 Tonnes X Cost Index	5 Dist. of Op. Expenses	6 Total Annual Op. Expenses
	%				%	million $
T3	4.03	1.000	824075	824075	5.74	48.9
T4	0.99		202440	0	0.00	
T3-2	1.10	0.699	224934	157229	1.10	9.3
T3-3	0.89	0.585	181992	106465	0.74	6.3
T3-4	0.35	0.548	71570	39220	0.27	2.3
3-S2	48.13	0.745	9841868	7332192	51.09	435.1
3-S3	3.17	0.638	648218	413563	2.88	24.5
3-S3,1L	24.52	0.605	5013975	3033455	21.14	180.0
3-S3-S2	5.94	0.643	1214641	781014	5.44	46.4
3-S2-3	0.93	0.776	190171	147573	1.03	8.8
Other	9.95	0.745	2034627	1515797	10.56	90.0
Total	100.00		20448510		100.00	851.7

Table M.4/ Macro Estimate, Sensitivity Analysis

	Impact on Trucking Industry, Ontario Quebec, and Atlantic Canada	
	Dollars (millions)	Percent of total operating expenses
SCENARIO #2		
1 Table 12.6	- 5.6 to 27.9	-0.06 to 0.31
2 rough/other = 40:60	- 7.8 to 17.5	-0.09 to 0.20
3 rough/other = 20:80	- 3.4 to 38.3	-0.04 to 0.43
4 rough = 0	1.0 to 59.2	0.01 to 0.66
5 domestic operating expenses only	- 4.9 to 24.8	-0.06 to 0.31
6 total destination tonnes	- 5.6 to 27.9	-0.06 to 0.31
7 Quebec freight dist.= Section #11	- 5.4 to 24.1	-0.06 to 0.27
SCENARIO #3		
1 Table 12.6	-11.3 to 56.5	-0.13 to 0.63
2 rough/other = 40:60	-15.8 to 35.4	-0.18 to 0.40
3 rough/other = 20:80	- 6.8 to 77.5	-0.08 to 0.87
4 rough = 0	2.1 to 119.7	0.02 to 1.34
5 domestic operating expenses only	- 9.9 to 50.1	-0.13 to 0.64
6 total destination tonnes	-11.3 to 56.5	-0.13 to 0.63
7 Quebec freight dist.= Section #11	-11.1 to 48.7	-0.12 to 0.55
SCENARIO #4		
1 Table 12.6	-17.3 to 101.8	-0.19 to 1.14
2 rough/other = 40:60	-26.0 to 64.4	-0.29 to 0.72
3 rough/other = 20:80	- 8.5 to 139.2	-0.09 to 1.56
4 rough = 0	9.1 to 214.0	0.10 to 2.40
5 domestic operating expenses only	-15.1 to 90.3	-0.19 to 1.14
6 total destination tonnes	-17.3 to 101.8	-0.19 to 1.14
7 Quebec freight dist.= Section #11	-17.4 to 88.4	-0.19 to 0.99
SCENARIO #5		
1 Table 12.6	15.0 to 52.6	0.17 to 0.59
2 rough/other = 40:60	15.0 to 52.6	0.17 to 0.59
3 rough/other = 20:80	15.0 to 52.6	0.17 to 0.59
4 rough = 0	15.0 to 52.6	0.17 to 0.59
5 domestic operating expenses only	13.0 to 45.4	0.16 to 0.58
6 total destination tonnes	15.0 to 52.6	0.17 to 0.59
7 Quebec freight dist.= Section #11	15.0 to 52.6	0.17 to 0.59

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